63-2-5

STOAT

297 344

LONG RANGE SEISMIC MEASUREMENTS

PROJECT 8.4

STOAT

9 JANUARY 1962

PREPARED FOR

ARPA PROJECT: *VELA-UNIFORM*

31 DECEMBER 1962

BY THE

AIR FORCE TECHNICAL APPLICATIONS CENTER

HQ-USAF (AFTAC)

WASHINGTON 25, D.C.

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This shot report is issued on behalf of the US Air Force (AFTAC), Department of Defense, to provide information which may prove of value in the study of data from nuclear tests.

The Air Force will not be responsible for information contained herein which may have been supplied by other organizations or contractors, and this document is subject to later revision as may be necessary.

CONTENTS

STOAT - NOUGAT SERIES

EVENT DESCRIPTION

DATE: 9 January 1962

TIME OF ORIGIN: 16:30:00.14Z

YIELD: 4.5 ± .6 kt

MAGNITUDE: m = 4.2

LOCATION:

Site: Area 3 - U3ap

Geographic Coordinates: Lat. 37° 02' 41" N; Long. 116° 02' 06" W

ENVIRONMENT:

Geological Medium: Alluvium

Shot Depth: 992 feet

Surface Elevation: 4021 feet

Shot Elevation: 3029 feet

COMPUTED EPICENTER (based on station spacing of approximately 1000 km):

Geographic Coordinates: Lat. 36° 57.6' N; Long. 116° 04.2' W

Time of Origin: 16:30:02.7Z

Depth: Restrained at zero after initial solution above surface.

Stations Used: HL ID, MV CL, BF CL, DR CO, LC NM.

COLLAPSE:

Time of Origin: 16:56:48Z

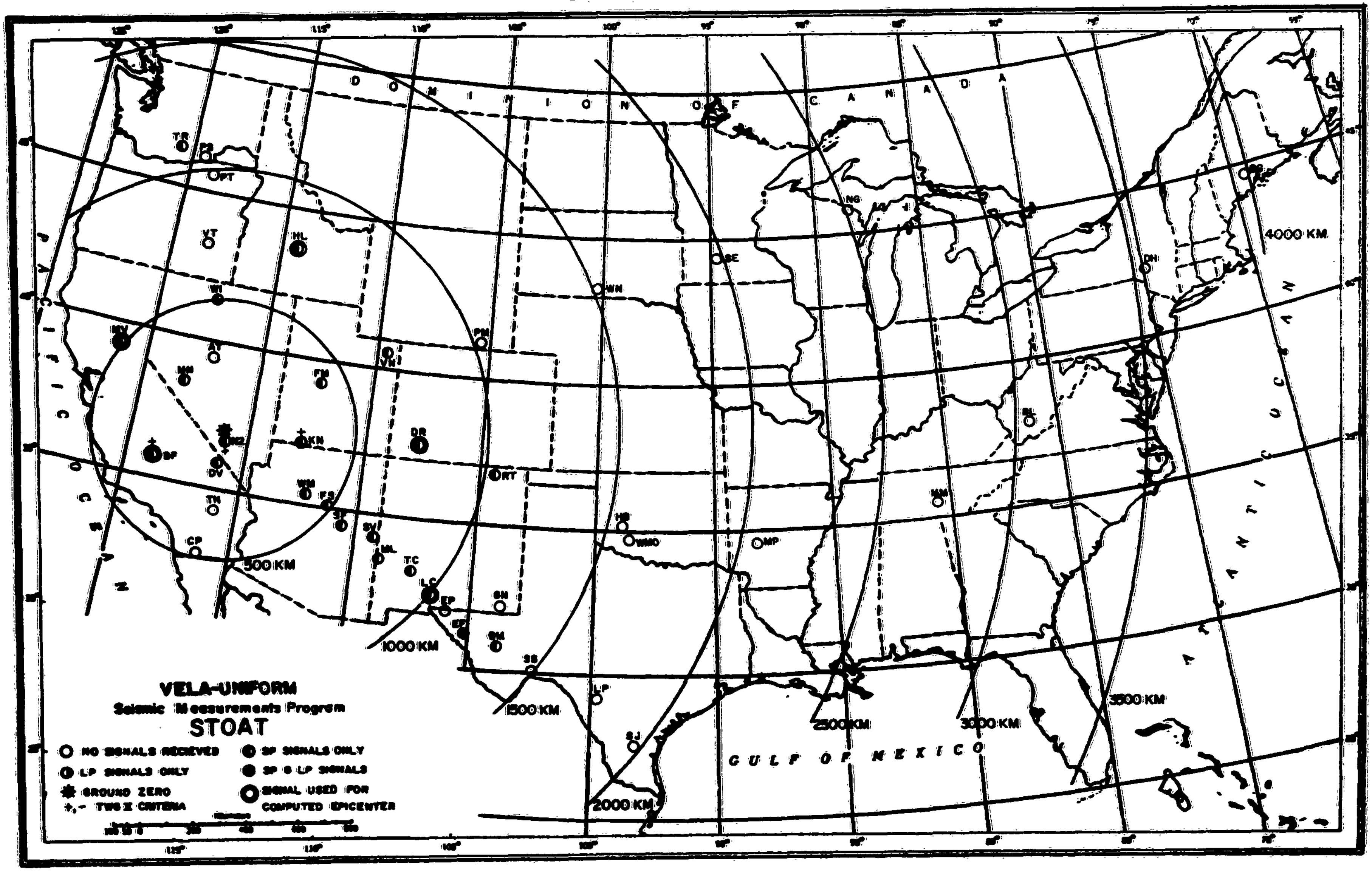
Magnitude: m = 3.2

LRSM Status Report
STOAT

Code	Station	SPZ	SPR	SPT	LPZ	LPR	LPT	Tape	Timing
N2 NV	Test Site, Nev	+	+	+	N	N	N	*	P
DV CL	Death Valley, Cal	+	+	+	I	I	I	*	P
MN NV	Mina, Nev	+	+	+	-	-	-	*	P
AT NV	Austin, Nev	I	I	I	I	I	I	I	I
KN UT	Kanab, Utah	+	+	+	-	-	-	*	P
BF CL	Bakersfield, Cal	+	+	+	-	-	-	*	S
TN CL	Twenty-Nine Palms, Cal	I	I	I	I	I	I	I	I
WM AZ	Williams, Ariz	+	+	+	-	-	-	*	S
FM UT	Fillmore, Utah	+	+	+	-	-	-	*	P
FS AZ	Flagstaff, Ariz	+	+	+	-	-	-	*	P
CP CL	Campo, Cal	I	I	I	I	I	I	*	I
WI NV	Winnemucca, Nev	+	+	+	-	-	-	*	P
MV CL	Marysville, Cal	+	+	+	-	-	-	*	S
SF AZ	Snowflake, Ariz	+	+	+	-	-	-	*	P
VN UT	Vernal, Utah	+	+	+	-	-	-	*	S
SV AZ	Springerville, Ariz	+	+	+	-	-	-	*	S
VT OR	Venator, Oregon	I	I	I	I	I	I	I	I
DR CO	Durango, Colo	+	+	+	-	-	-	*	P
HL ID	Hailey, Idaho	+	+	+	-	-	-	*	P
ML NM	Mogollon, N.M.	+	+	+	-	-	-	*	S
TC NM	Truth or Consequences, N.M.	+	+	+	-	-	-	*	P
PT OR	Pendleton, Oregon	I	I	I	I	I	I	I	I
LC NM	Las Cruces, N.M.	+	+	+	-	-	-	*	S
PM WY	Pole Mountain, Wyo	-	-	-	-	-	-	*	P
PS WA	Paterson, Wash	-	I	I	-	I	I	*	P
RT NM	Raton, N.M.	+	+	+	-	-	-	*	P
EP TX	El Paso, Texas	-	-	-	I	I	I	I	P
TR WA	Toppenish Ridge, Wash	+	I	I	-	I	I	*	P
EF TX	Eagle Flat, Texas	+	+	+	I	I	I	*	P
GN NM	Gnome, N.M.	-	-	-	-	-	-	*	P
BM TX	Balmorhea, Texas	I	+	+	I	I	I	*	P
SS TX	Sanderson, Texas	-	-	-	I	-	-	*	S
WN SD	Winner, S.D.	-	-	-	-	I	I	*	S
HB OK	Hobart, Okla	-	-	-	-	-	-	*	P
WMO	Wichita Mountains Observatory, Okla	-	-	-	-	-	-	*	P
LP TX	La Pryor, Texas	-	-	-	-	-	-	*	P
SJ TX	San Jose, Texas	-	-	-	-	-	-	*	P
SE MN	Sleepy Eye, Minn	-	-	-	-	-	I	*	P
MP AR	Mountain Pine, Ark	-	-	-	-	-	-	*	S
NG WS	Niagara, Wis	-	-	-	-	-	-	*	P
MM TN	McMinnville, Tenn	-	-	-	I	I	I	*	P
BL WV	Beckley, W.Va.	-	-	-	-	-	-	*	P
DH NY	Delhi, N.Y.	-	-	-	I	I	-	*	P
BG ME	Bangor, Maine	-	-	-	-	I	I	*	P

* (Operational)
I (Inoperative)
P (Primary timing system)
S (Secondary timing system)
\+ (Signal)
\- (No signal)

UNITED STATES



4. Introduction.

A long range seismic measurements (LRSM) program was established under VELA-UNIFORM Project 8.4 to record and analyze short-period and long-period seismic data from a planned series of U.S. underground nuclear tests. These, and other data, will be used by VELA-UNIFORM participants for studying and developing methods for distinguishing between explosive and earthquake sources.

The purpose of this report is to provide an analysis of the LRSM film seismograms from 40 mobile field teams, from the Wichita Mountains Seismological Observatory (WMO), Oklahoma, and from several experimental or temporary stations operated in connection with existing AFTAC commitments.

5. Instrumentation and Procedure.

Instrumentation at each of the 40 mobile stations consists of three-component short-period Benioff and three-component Sprengnether long-period seismographs. Shots are recorded on 35 millimeter film and on one-inch 14 channel magnetic tape. All of these stations are equipped to record WWV continuously in order to provide accurate time control. Calibration is accomplished once each day and just prior to each shot at operating settings. Specific details of the instrumentation and operating procedures for these stations are given in "Routine Operating Instructions", which may be obtained from AFTAC or from The Geotechnical Corporation, Dallas, Texas.

The observatory WMO also has both long and short-period three-component instrumentation in addition to its other specialized facilities. The noise survey stations (TR WA) and PS WA) record only vertical components of both long and short-period.

A status report for STOAT is included as Table I, placed opposite the operations map, Figure 1. This report gives the names of each of 44 stations, and indicates which were operational and which recorded usable signals.

Station site information is presented in Appendix I(A). This includes the station name and code, the geographic coordinates, distances and azimuths involved, the station elevations, and the type of instruments in use at each location.

The unified magnitude (m) computations for distances less than 16° are based on AFTAC extensions of Gutenberg's tables.* For this purpose, points from 10° to 16° were read from a curve in the Gutenberg-Richter paper and an inverse cube relationship was used to extrapolate from 2° to 10°. A table of the distance factors (B) is provided in Appendix I(B).

An explanation of the procedures for amplitude measurements used in this report is illustrated in Appendix II. First motion is read zero to peak and other amplitudes are half peak-to-trough values, all reduced to millimicrons. The amplitude divided by the period is reported as A/T.

Appendix III quotes the Technical Working Group II (TWG-II) first motion criteria, and includes diagrams illustrating the elements involved in determining a compression or rarefaction where satisfactory measurements can be made.

As a measure of the effectiveness of a network of hypothetical control stations having approximately 1000 km spacing, a comparison is made between the actual location of the shot and its computed hypocenter as determined

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*Gutenberg, B. and Richter, C. F., Magnitude and Energy of Earthquakes, Ann. Geofis., 9 (1956), pp. 1-15.

by a digital computer. Best-fit values of latitude, longitude, depth of focus, and time of origin are determined statistically by a least squares technique. This utilizes a Jeffreys-Bullen travel time curve as modified by Herrin in 1961 on the basis of Pacific surface-focus recordings. Precision of the computation is limited primarily by the accuracy of arrival times, the validity of the standard travel time curve, and by local velocity deviations. Since the method is based on P wave arrivals, this particular program does not make use of later phases such as pP and S in the determination of depth or location. Results are shown on the event information sheet.

6. Data and Results.

Table II summarizes the measurements made of the principal phases of the STOAT event. Included are the Pn and P arrival times, the maximum amplitudes (A/T) of the Pn or P and Pg motion seen on the short-period vertical instruments and the maximum amplitudes (A/T) of the Lg phase as measured in the short-period tangential component. Short-period signals from this event were recorded on film by 22 stations and on tape only at one station, CP CL. No long-period phases were observed.

Also shown in Table II and in Figure 2 are unified magnitudes (m) where measurable. First motion criteria (TWG-II) were applicable for three stations.

The travel time residuals from the Pn and P phase were within the usual limits (see Figure 3). The amplitudes of Pn and Pg, Pg, and Lg are shown in Figures 4, 5, and 6. These graphs show lines proportional to the inverse cube of the distance visually fitted through the observed points.

Attached to the report are illustrative seismograms showing the signals recorded at a number of locations. Useful signals from STOAT were recorded to a distance of 1313 km.

Following STOAT by about 27 minutes, a collapse event was recorded with measurable signals at 16 stations to a distance of 1005 km. Table III shows the maximum amplitudes of the Pg and Lg phases. No long-period signals were observed from the collapse event.

The amplitudes of Pg and Lg for the collapse are shown in Figures 7 and 8. The relative amplitude of the Pg and Lg phases for STOAT and the collapse are both in the approximate ratio of 9 to 1. This ratio was used to determine the collapse magnitude of 3.2 as compared to the STOAT magnitude of 4.2. Representative seismograms for the collapse event are included with this report.

Principal Phases
STOAT
9 January 1962
16:30:00.1Z

Code	Station	Distance km	Inst	Gain(K) (film x 10)	Phase	Observed Travel Time min.	sec.	Period T sec.	Max Ampl A/T	TWG II First Motion	Magnitude m	Record Attached
N2 NV	Test Site, Nevada	46	SP-Z	11.4	Pg	30	07.9			C		
			SP-Z	11.4	Pg max			(0.4)	(1845.)			
			SP-T	11.1	Lg max			0.6	6830.			
DV CL	Death Valley, Cal	135	SP-Z	15.6	e(Pn)	30	22.7	0.3	412.			
			SP-Z	15.6	Pg max			0.4	2180.			
			SP-T	16.0	Lg max			0.5	3640.			
MN NV	Mina, Nevada	242	SP-Z	74.0	ePn	30	37.5	0.3	116.		4.4	
			SP-Z	74.0	Pg max			--	--			
			SP-T	70.0	Lg max			0.6	587.			
KN UT	Kanab, Utah	285	SP-Z	95.0	iPn	30	43.1	0.5	104.	C	4.3	
			SP-Z	95.0	Pg max			0.5	740.			
			SP-T	68.0	Lg max			0.6	578.			
BF CL	Bakersfield, Cal	296	SP-Z	534.	iPn	30	44.6	0.4	(35.9)	C	4.1	
			SP-Z	534.	Pg max			--	--			
			SP-T	588.	Lg max			--	--			
WM AZ	Williams, Arizona	388	SP-Z	310.	ePn	30	56.9	0.3	37.3		4.5	
			SP-Z	310.	Pg max			0.4	(200.)			
			SP-T	348.	Lg max			--	--			
FM UT	Fillmore, Utah	413	SP-Z	294.	ePn	30	58.4	0.3	8.23		3.9	a
			SP-Z	294.	Pg max			0.4	85.0			
			SP-T	--	Lg max			--	--			
FS AZ	Flagstaff, Arizona	479	SP-Z	255.	ePn	31	09.0	0.3	19.0		4.5	
			SP-Z	255.	Pg max			--	--			
			SP-T	252.	Lg max			(0.7)	(63.4)			

Table II

Principal Phases
STOAT
9 January 1962
16:30:00.1Z

Code	Station	Distance km	Inst	Gain(K) (film x 10)	Phase	Observed Travel Time min.	Observed Travel Time sec.	Period T sec.	Max Ampl A/T	TWG II First Motion	Magnitude m	Record Attached
CP CL	Campo, Cal	480	SP-Z	(film inop - see tape playback)								a
			SP-T	" " " " "								
WI NV	Winnemucca, Nevada	494	SP-Z	564.	ePn	31	09.4	0.4	4.81		3.9	a
			SP-Z	564.	Pg max			(0.5)	(89.8)			
			SP-T	472.	Lg max			(0.6)	(122.)			
MV CL	Marysville, Cal	524	SP-Z	359.	ePn	31	(14.9)	0.5	3.15		3.7	b
			SP-Z	359.	Pg max			0.5	17.8			
			SP-T	340.	Lg max			0.6	49.9			
SF AZ	Snowflake, Arizona	577	SP-Z	215.	ePn	31	21.5	(0.4)	(26.2)		4.9	
			SP-Z	215.	Pg max			(0.5)	(65.8)			
			SP-T	220.	Lg max			(0.6)	(57.5)			
VN UT	Vernal, Utah	680	SP-Z	157.	ePn	--	--	(0.4)	(22.6)		(4.0)	
			SP-Z	157.	Pg max			(0.5)	(38.3)			
			SP-T	186.	Lg max			(0.5)	(18.2)			
SV AZ	Springerville, Arizona	700	SP-Z	89.5	ePn	31	37.3	0.3	3.00		4.1	
			SP-Z	89.5	Pg max			0.5	39.9			
			SP-T	100.	Lg max			0.6	47.8			
DR CO	Durango, Colorado	733	SP-Z	Unk	ePn	31	38.5	0.4	--		--	b
			SP-Z	Unk	Pg max			--	--			
			SP-T	Unk	Lg max			--	--			
HL ID	Hailey, Idaho	749	SP-Z	348.	iPn	31	43.9	0.4	1.50		3.9	
			SP-Z	348.	Pg max			0.4	31.1			
			SP-T	296.	Lg max			0.6	17.1			
ML NM	Mogollon, N.M.	769	SP-Z	260.	ePn	31	52.0	0.4	1.60		4.0	
			SP-Z	260.	Pg max			0.5	24.6			
			SP-T	221.	Lg max			0.6	11.4			

Table II

Principal Phases
STOAT
9 January 1962
16:30:00.12

Code	Station	Distance km	Inst	Gain(K) (film x 10)	Phase	Observed Travel Time min.	sec.	Period T sec.	Max Ampl A/T	TWG II First Motion	Magnitude m	Record Attached
TC NM	Truth or Consequences, N.M.	891	SP-Z	255.	ePn	32	04.7	(0.4)	(1.64)		(4.2)	
			SP-Z	255.	Pg max			0.6	46.7			
			SP-T	190.	Lg max			0.6	21.8			
LC NM	Las Cruces, N.M.	1005	SP-Z	396.	ePn	32	16.0	0.4	1.05		4.2	a
			SP-Z	396.	Pg max			0.7	7.85			
			SP-T	400.	Lg max			0.7	3.29			
RT NM	Raton, N.M.	1041	SP-Z	58.5	ePn	--	--	--	--			
			SP-Z	58.5	Pg max			0.6	12.3			
			SP-T	96.5	Lg max			0.7	9.75			
TR WA	Toppenish Ridge, Wash	1090	SP-Z	550.	ePn	(32	25.4)	(0.8)	(2.4)		(4.7)	
			SP-Z	550.	Pg max			(0.8)	(3.0)			
EF TX	Eagle Flat, Texas	1197	SP-Z	472.	eP	--	--	--	--			
			SP-Z	472.	Pg max			0.8	3.05			
			SP-T	492.	Lg max			(1.0)	(3.05)			
BM TX	Balmorhea, Texas	1313	SP-R	134.	eP	--	--	--	--			
			SP-R	134.	Pg max			(0.6)	(3.37)			
			SP-T	247.	Lg max			(0.7)	(2.66)			

a (station seismograms to be included in Nevada Test Site reports when possible)
b (additional station seismograms of interest)
-- (signal not measurable)
( ) (doubtful values)

Table II

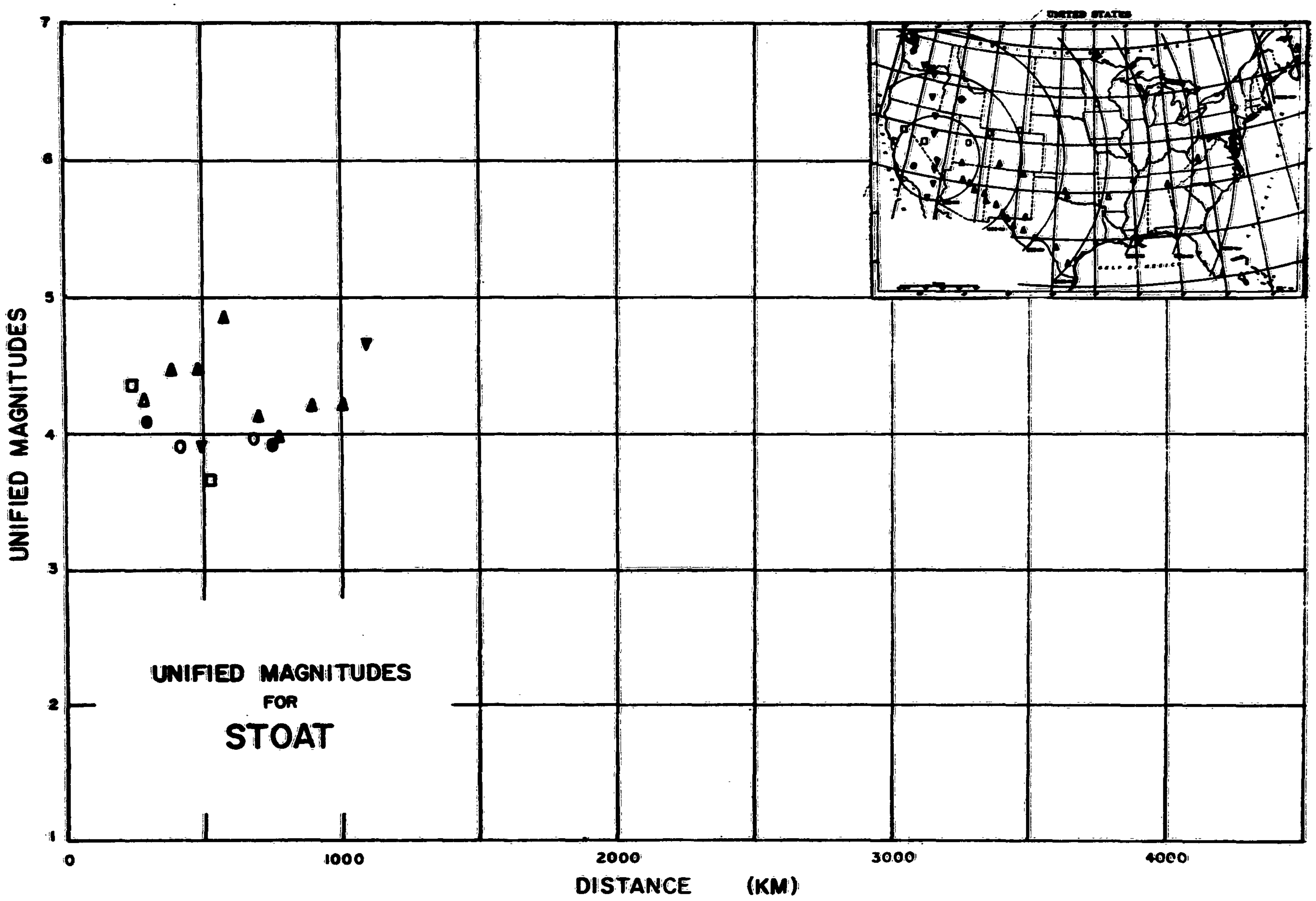
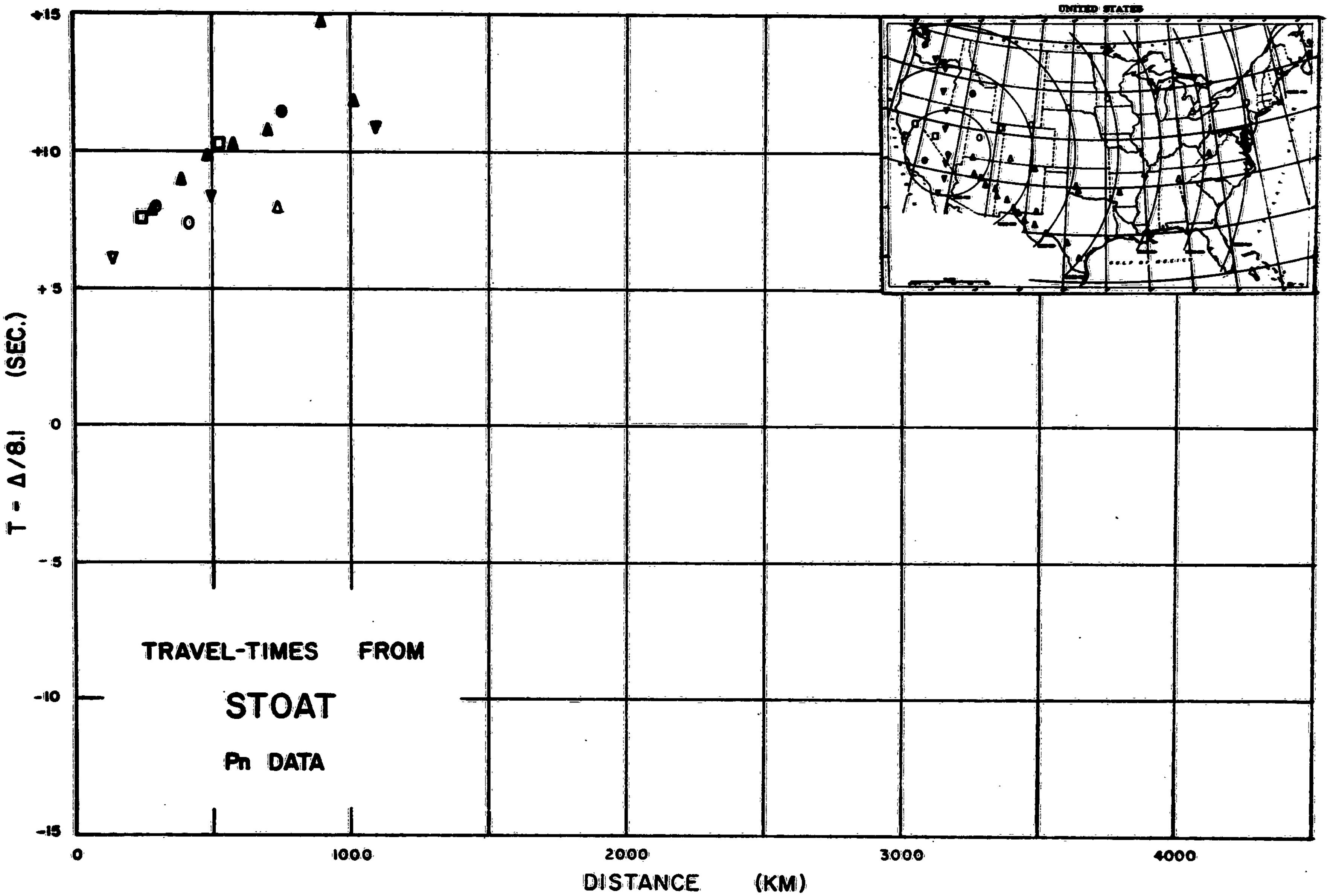

UNITED STATES
UNIFIED MAGNITUDES
1
2
3
4
5
6
7
0
1000
2000
3000
4000
DISTANCE (KM)
UNIFIED MAGNITUDES
FOR
STOAT

Figure 2



+15
+10
+5
0
-5
-10
-15
T - Δ/8.1 (SEC.)
0
1000
2000
3000
4000
DISTANCE (KM)
TRAVEL-TIMES FROM
STOAT
Pn DATA
UNITED STATES

Figure 3

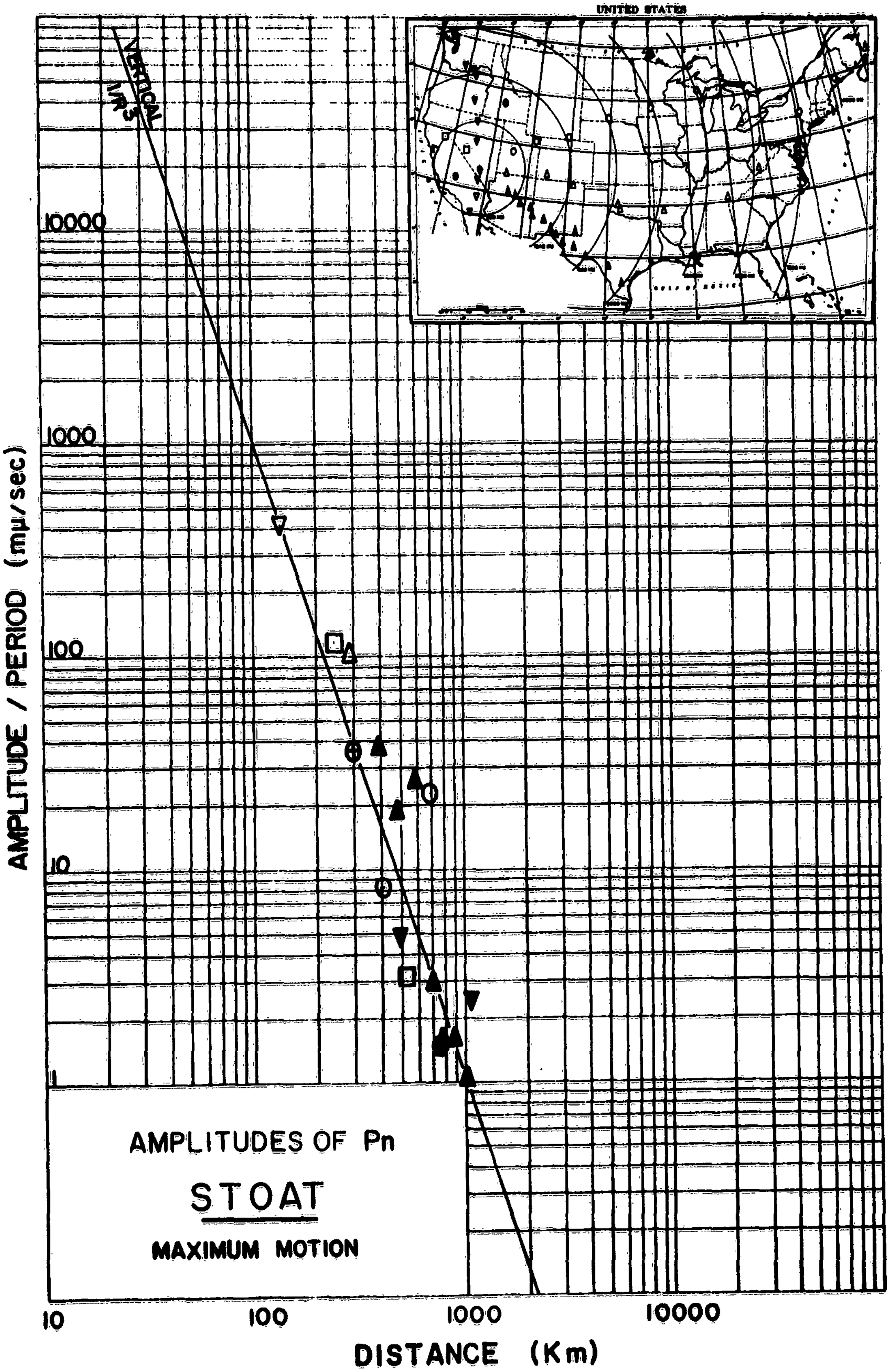

UNITED STATES
VERTICAL
1/R3
10000
1000
100
10
1
AMPLITUDE / PERIOD (mμ/sec)
AMPLITUDES OF Pn
STOAT
MAXIMUM MOTION
10
100
1000
10000
DISTANCE (Km)

Figure 4

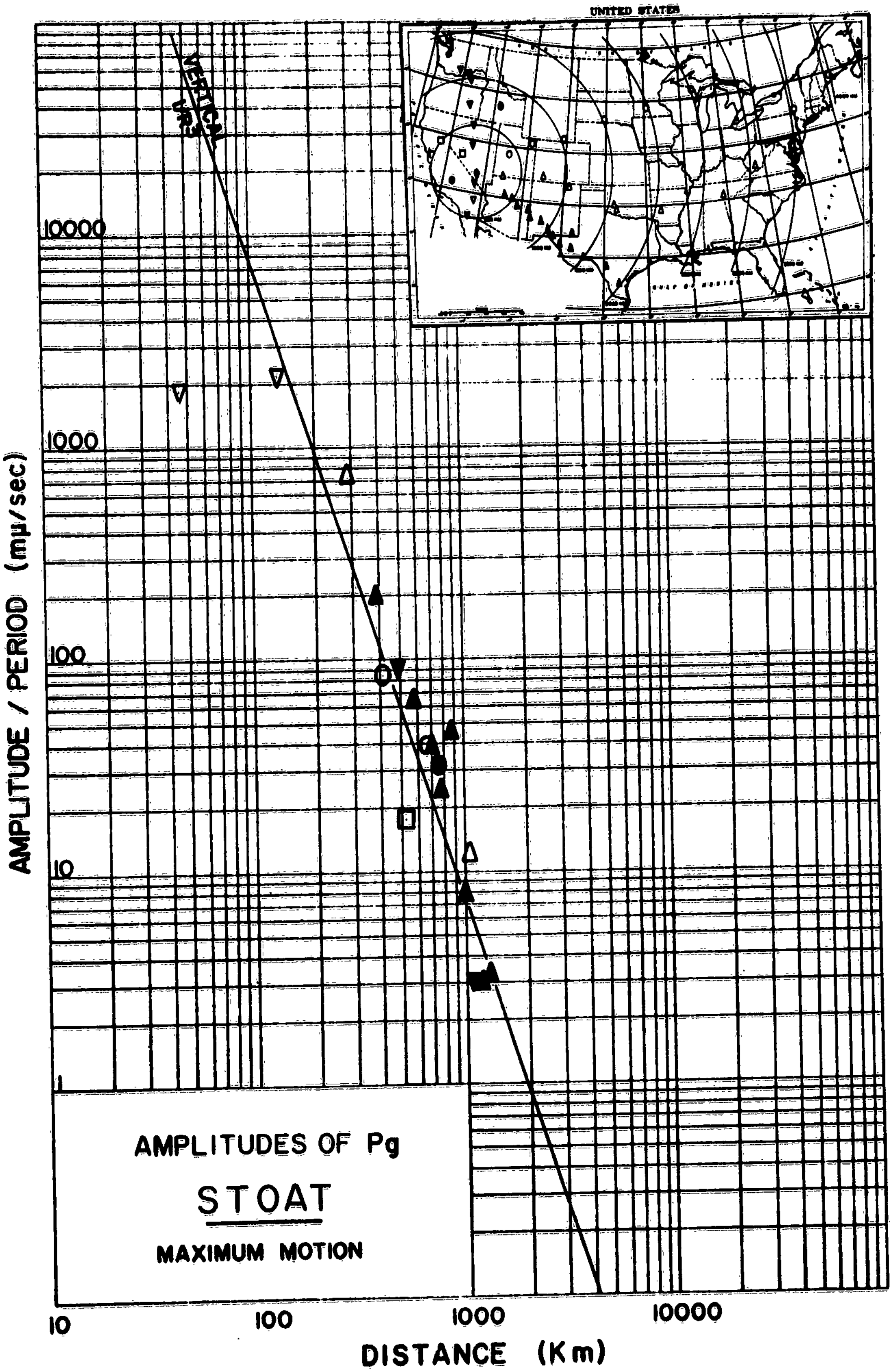

UNITED STATES
VERTICAL
VR3
AMPLITUDE / PERIOD (mμ/sec)
10000
1000
100
10
1
AMPLITUDES OF Pg
STOAT
MAXIMUM MOTION
10
100
1000
10000
DISTANCE (Km)

Figure 5

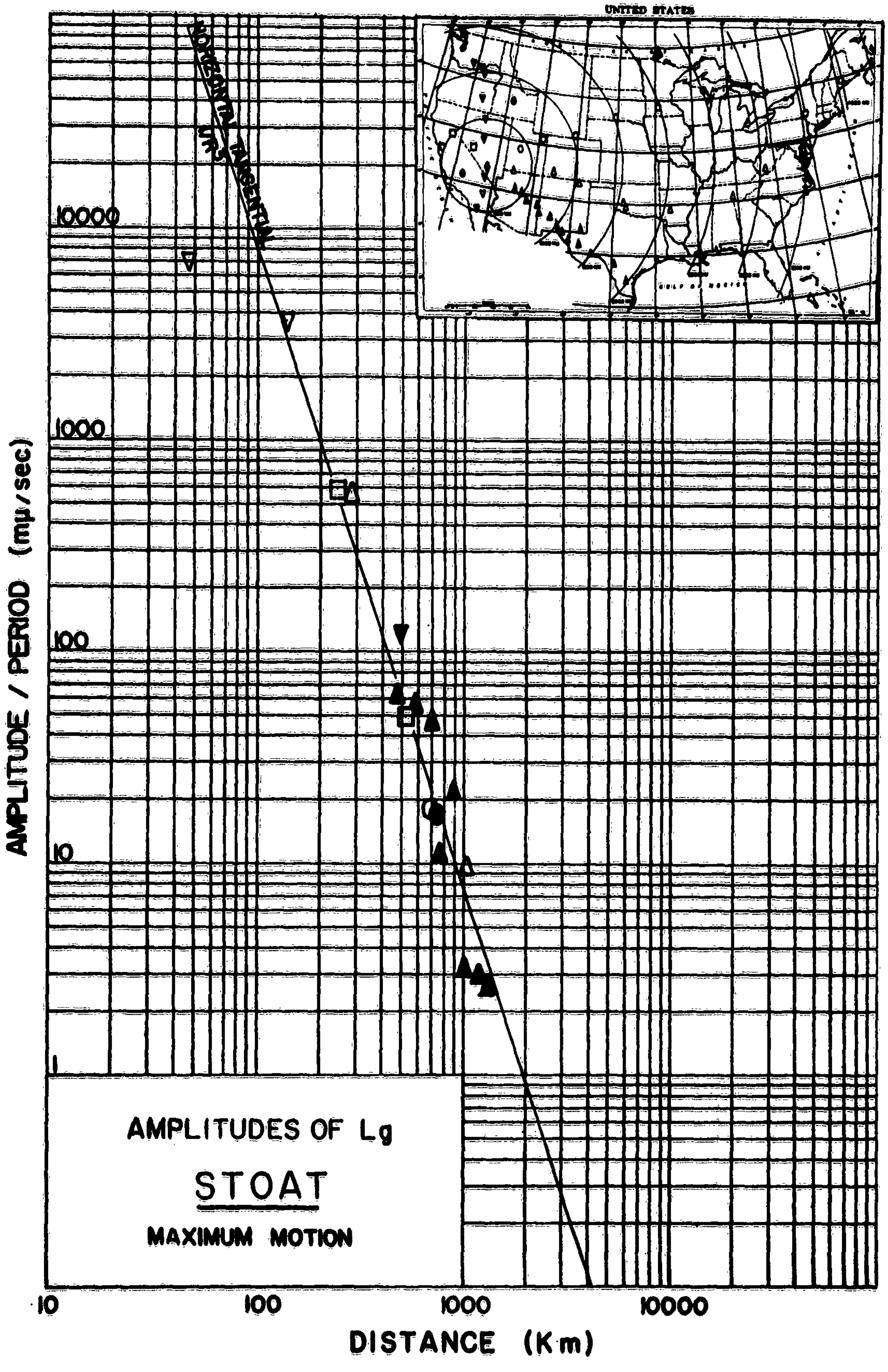

UNITED STATES
HORIZONTAL TANGENTIAL
LR3
10000
1000
100
10
1
AMPLITUDE / PERIOD (mμ/sec)
AMPLITUDES OF Lg
STOAT
MAXIMUM MOTION
10
100
1000
10000
DISTANCE (Km)

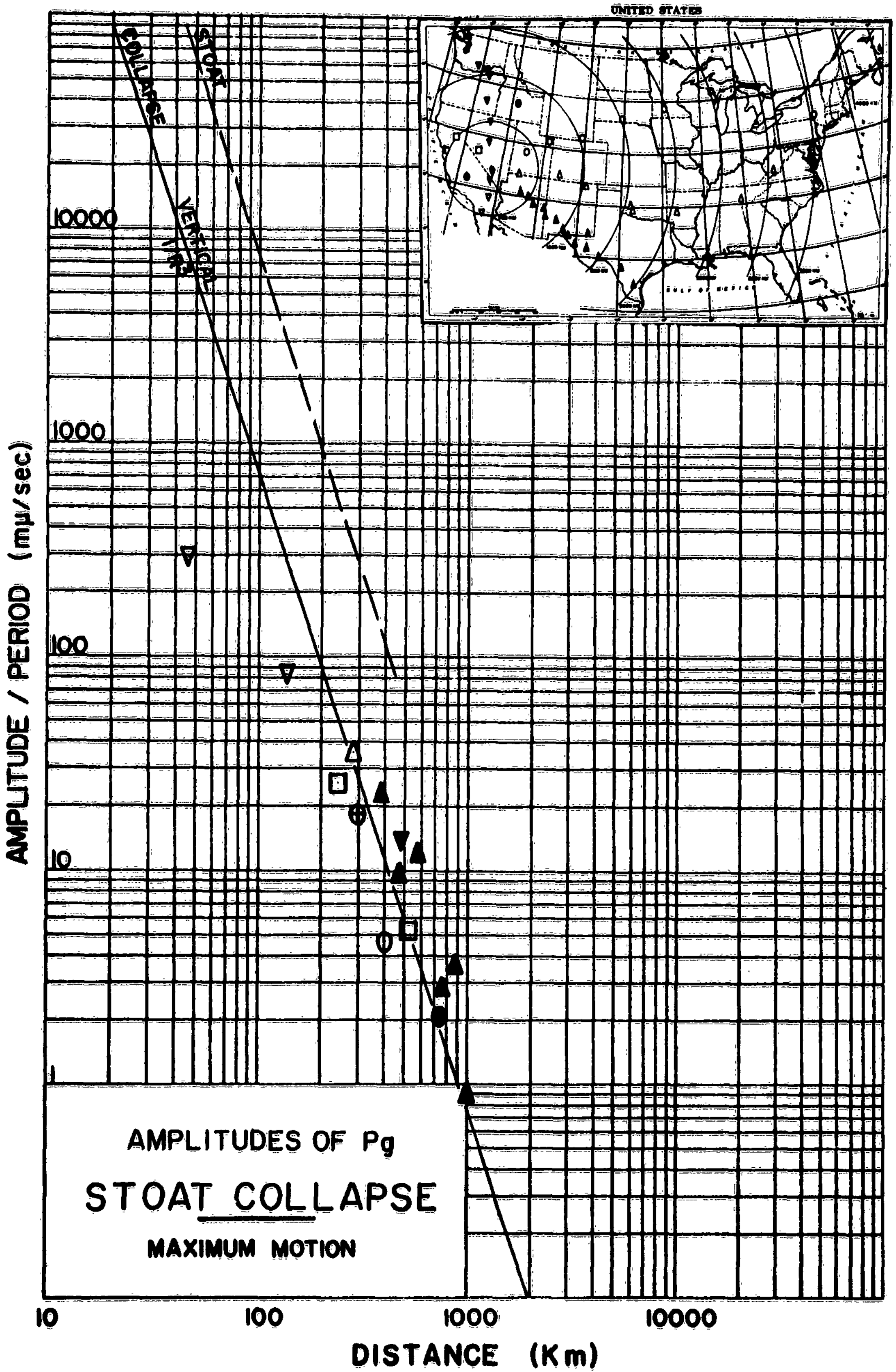
Figure 6

Collapse Phases
STOAT
9 January 1962
16:56:48Z

Code	Station	Distance km	Inst.	Pg Period T (sec)	Max Pg Ampl A/T	Inst.	Lg Period T (sec)	Max Lg Ampl A/T	Record Attached
N2 NV	Test Site, Nev	46	SP-Z	0.6	293.	SP-T	0.7	610.	
DV CL	Death Valley, Cal	135	SP-Z	0.5	84.0	SP-T	0.7	353.	
MN NV	Mina, Nev	242	SP-Z	0.5	25.4	SP-T	0.8	61.8	
KN UT	Kanab, Utah	285	SP-Z	0.6	36.1	SP-T	0.6	58.4	
BF CL	Bakersfield, Cal	296	SP-Z	0.7	18.3	SP-T	0.8	13.0	
WM AZ	Williams, Ariz	388	SP-Z	0.5	23.1	SP-T	0.6	21.8	
FM UT	Fillmore, Utah	413	SP-Z	0.7	4.79	SP-T	--	--	a
FS AZ	Flagstaff, Ariz	479	SP-Z	0.6	9.93	SP-T	0.7	7.10	
CP CL	Campo, Calif	480	(film inop - see tape playback)						a
WI NV	Winnemucca, Nev	494	SP-Z	0.5	13.7	SP-T	0.7	39.1	a
MV CL	Marysville, Cal	524	SP-Z	0.5	5.24	SP-T	0.7	15.5	
SF AZ	Snowflake, Ariz	577	SP-Z	(0.5)	(12.2)	SP-T	(0.7)	(12.0)	
HL ID	Hailey, Idaho	749	SP-Z	0.6	2.07	SP-T	0.7	2.22	
ML NM	Mogollon, N.M.	769	SP-Z	0.5	2.90	SP-T	(0.7)	(1.70)	
TC NM	Truth or Consequences, N.M.	891	SP-Z	0.7	3.69	SP-T	(0.7)	(2.97)	
LC NM	Las Cruces, N.M.	1005	SP-Z	(0.6)	(0.91)	SP-T	--	--	

a (station seismograms usually included in Nevada Test Site reports)
-- (not measurable)
( ) (doubtful values)

Table III



UNITED STATES
STOAT
COLLAPSE
VERTICAL
1/R
10000
1000
100
10
1
AMPLITUDE / PERIOD (mμ/sec)
AMPLITUDES OF Pg
STOAT COLLAPSE
MAXIMUM MOTION
10
100
1000
10000
DISTANCE (Km)

Figure 7

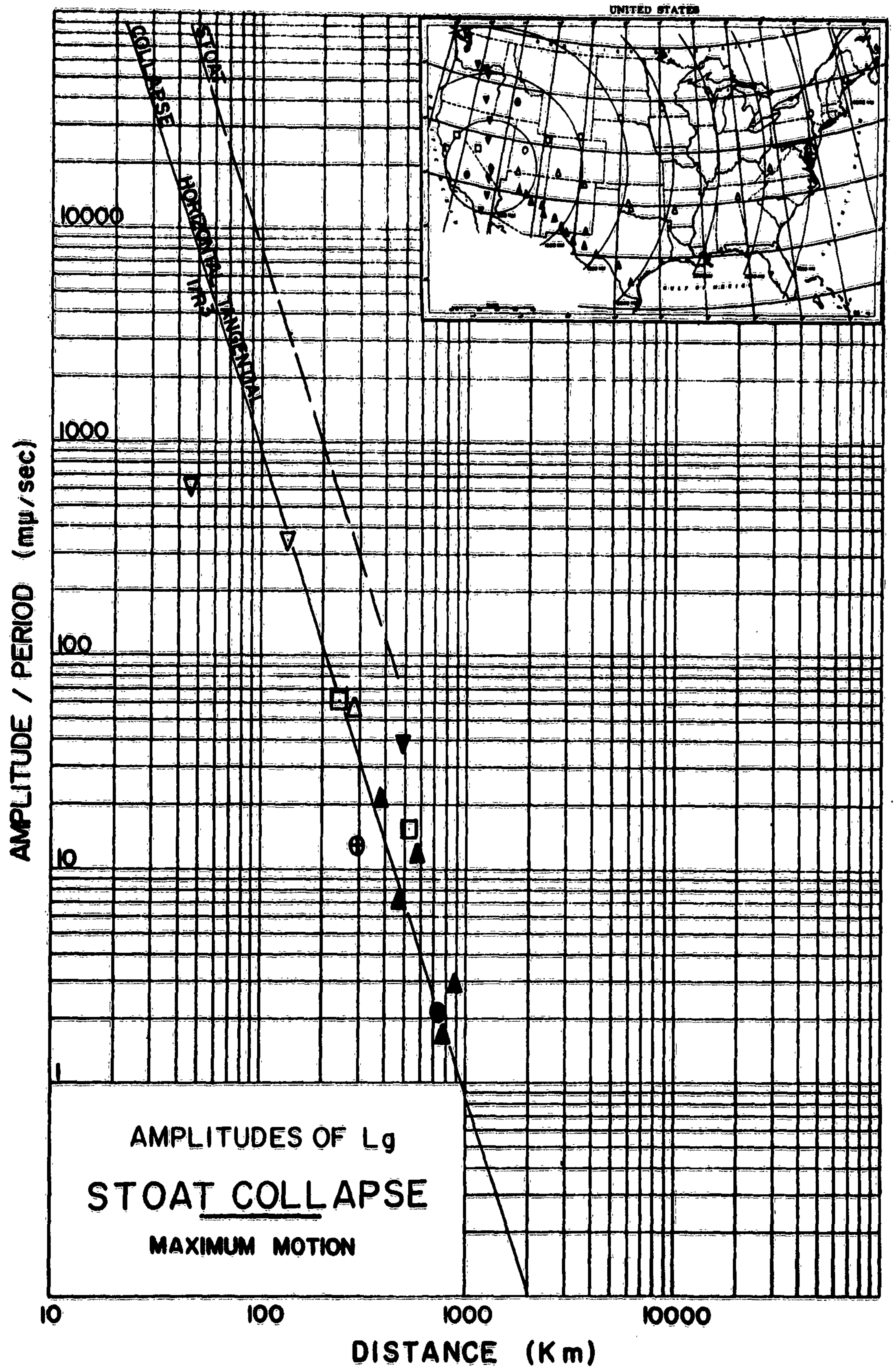

UNITED STATES
COLLAPSE
STOAT
HORIZONTAL TANGENTIAL
1/R³
10000
1000
100
10
1
AMPLITUDE / PERIOD (mμ/sec)
AMPLITUDES OF Lg
STOAT COLLAPSE
MAXIMUM MOTION
10
100
1000
10000
DISTANCE (Km)

Figure 8

LRSM Site Information
STOAT

Code	Station	Distance km	Geog. Latitude	Geog. Longitude	Elev. km	Computed Azimuth Epi-Sta	Computed Azimuth Sta-Epi	Installed Azimuth Radial	Installed Azimuth Tang.	Large or Small SP	LP Inst
N2 NV	Test Site, Nev	46	36°38'00"N	115°58'59"W	0.500	174°	354°	(158)°	(248)°	L	
DV CL	Death Valley, Cal	135	35 50 00	116 06 06	0.792	183	3	177	267	L	
MN NV	Mina, Nev	242	38 26 10	118 08 53	1.524	310	129	308	38	L	x
AT NV	Austin, Nev	282	39 28 53	117 04 26	1.981	342	161	343	73	L	
KN UT	Kanab, Utah	285	37 01 22	112 49 39	1.737	90	271	95	185	L	x
BF CL	Bakersfield, Cal	296	35 39 12	118 51 06	0.564	239	58	233	323	L	x
TN CL	Twenty Nine Palms, Cal	316	34 11 54	115 57 00	0.533	179	359	176	266	L	
WM AZ	Williams, Ariz	388	35 25 04	112 12 54	1.920	117	299	120	210	L	x
FM UT	Fillmore, Utah	413	39 13 06	112 12 25	1.890	53	235	58	148	S	x
FS AZ	Flagstaff, Ariz	479	35 04 09	111 18 34	1.889	116	299	120	210	L	x
CP CL	Campo, Cal	480	32 43 44	116 22 16	1.189	184	4	182	272	L	x
WI NV	Winnemucca, Nev	494	41 21 02	117 27 30	1.524	346	165	346	76	L	x
MV CL	Marysville, Cal	524	39 12 47*	121 17 35*	0.183*	299	116	295	25	L	x
SF AZ	Snowflake, Ariz	577	34 26 19	110 30 52	1.981	118	302	123	213	L	x
VN UT	Vernal, Utah	680	40 30 31	109 34 45	1.890	54	238	65	155	S	x
SV AZ	Springerville, Ariz	700	34 10 32	109 08 49	2.134	115	299	120	210	L	x
VT OR	Venator, Ore	708	43 08 49	118 25 23	1.432	344	162	343	73	L	
DR CO	Durango, Colo	733	37 27 53	107 47 00	2.225	84	269	90	180	S	x
HL ID	Hailey, Idaho	749	43 38 52	114 16 02	1.829	11	192	16	106	L	x
ML NM	Mogollon, N.M.	769	33 24 53	108 50 11	1.646	119	304	124	214	S	x
TC NM	Truth or Consequences, N.M.	891	33 11 03	107 27 42	1.524	116	301	122	212	L	x
PT OR	Pendleton, Oregon	981	45 36 40	118 53 02	0.411	347	165	346	76	L	
LC NM	Las Cruces, N.M.	1005	32 24 08	106 35 58	1.585	118	303	124	214	L	x
PM WY	Pole Mountain, Wyo	1031	41 12 27	105 21 39	2.469	60	247	68	158	S	x
PS WA	Paterson, Wash	1038	46 01 54	119 26 12	0.500	345	163			JM	x
RT NM	Raton, N.M.	1041	36 43 46	104 21 37	1.951	88	275	354	84	S	x
EP TX	El Paso, Texas	1084	31 55 58	105 58 00	1.615	119	304	125	215	L	
TR WA	Toppenish Ridge, Wash	1090	46 15 48	120 31 00	0.500	341	158			JM	x
EF TX	Eagle Flat, Texas	1197	31 10 35	105 07 48	1.432	120	306	126	216	L	
GN NM	Carlsbad, N.M.	1235	32 15 45	103 51 25	1.036	112	299	119	209	S	x

LRSM Site Information
STOAT

Code	Station	Distance km	Geog. Latitude	Geog. Longitude	Elev. km	Computed Azimuth Epi-Sta	Computed Azimuth Sta-Epi	Installed Azimuth Radial	Installed Azimuth Tang.	Large or Small SP	LP Inst
BM TX	Balmorhea, Texas	1313	30°55'35"N	103°51'18"W	1.067	118°	304°	125°	215°	L	
SS TX	Sanderson, Texas	1490	30 01 17	102 19 41	0.731	118	305	126	216	L	x
WN SD	Winner, S.D.	1512	43 15 08	100 11 46	0.792	58	248	69	159	S	x
HB OK	Hobart, Okla	1554	35 10 35	98 54 37	0.491	93	283	103	193	S	x
WMO	Wichita Mountains Observatory, Okla	1594	34 43 05	98 35 21	0.505	94	284	E	N	JM	x
LP TX	La Pryor, Texas	1755	29 10 47	99 40 35	0.274	115	304	131	221	L	x
SJ TX	San Jose, Texas	1964	27 36 43	98 18 46	0.114	117	307	127	217	S	x
SE MN	Sleepy Eye, Minn	1975	44 24 51	94 39 55	0.244	59	253	73	163	S	x
MP AR	Mountain Pine, Ark	2081	34 36 06	93 08 45	0.335	91	284	105	195	S	x
NG WS	Niagara, Wis	2509	45 45 34	88 09 15	0.396	59	257	78	168	S	x
MM TN	McMinnville, Tenn	2728	35 33 52	85 35 20	0.381	84	282	103	193	S	
BL WV	Beckley, W.Va.	3058	37 47 56	81 18 36	0.610	78	279	100	190	S	x
DH NY	Delhi, N.Y.	3545	42 14 39	74 53 18	0.652	68	275	95	185	S	x
BG ME	Bangor, Maine	3982	44 38 04	69 13 17	0.183	63	274	95	185	S	x

*(MV CL remains at the same location but previously used position of 39°13'36" N and 121°18'05" W and previously used elevation of 0.610 recently revised to values shown in this table.)

L (Large Benioff instruments)
S (Small Benioff instruments)
JM (Johnson-Matheson short-period instruments)

Unified Magnitudes from Pn or P Waves

Unified Magnitude: $m = \log_{10}(A/T) + B$

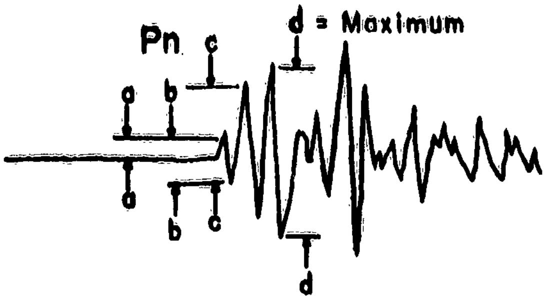
where
A = zero to peak ground motion in millimicrons
$= \frac{(mm)(1000)}{K}$
T = signal period in seconds
B = distance factor (see Table below)
mm = record amplitude in millimeters zero to peak
K = magnification in thousands at signal frequency

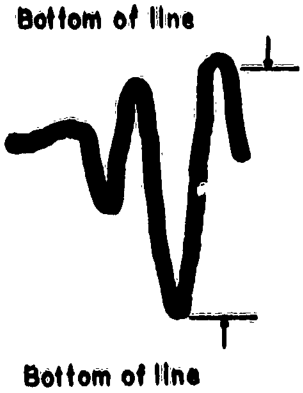
Table of Distance Factors (B) for Zero Depth

Dist (deg)	B	Dist (deg)	B	Dist (deg)	B	Dist (deg)	B
0°	-	30°	3.6	60°	3.8	90°	4.0
1	-	31	3.7	61	3.9	91	4.1
2	2.2	32	3.7	62	4.0	92	4.1
3	2.7	33	3.7	63	3.9	93	4.2
4	3.1	34	3.7	64	4.0	94	4.1
5	3.4	35	3.7	65	4.0	95	4.2
6	3.6	36	3.6	66	4.0	96	4.3
7	3.8	37	3.5	67	4.0	97	4.4
8	4.0	38	3.5	68	4.0	98	4.5
9	4.2	39	3.4	69	4.0	99	4.5
10	4.3	40	3.4	70	3.9	100	4.4
11	4.2	41	3.5	71	3.9	101	4.3
12	4.1	42	3.5	72	3.9	102	4.4
13	4.0	43	3.5	73	3.9	103	4.5
14	3.6	44	3.5	74	3.8	104	4.6
15	3.3	45	3.7	75	3.8	105	4.7
16	2.9	46	3.8	76	3.9		
17	2.9	47	3.9	77	3.9		
18	2.9	48	3.9	78	3.9		
19	3.0	49	3.8	79	3.8		
20	3.0	50	3.7	80	3.7		
21	3.1	51	3.7	81	3.8		
22	3.2	52	3.7	82	3.9		
23	3.3	53	3.7	83	4.0		
24	3.3	54	3.8	84	4.0		
25	3.5	55	3.8	85	4.0		
26	3.4	56	3.8	86	3.9		
27	3.5	57	3.8	87	4.0		
28	3.6	58	3.8	88	4.1		
29	3.6	59	3.8	89	4.0		

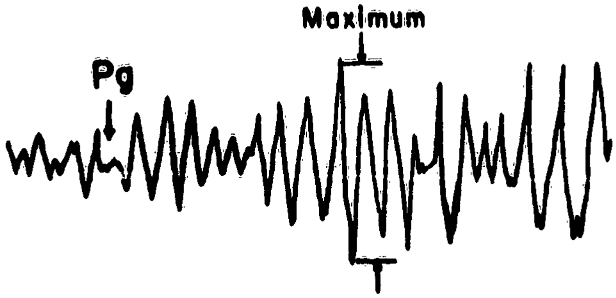
SEISMIC ANALYSIS DIAGRAM

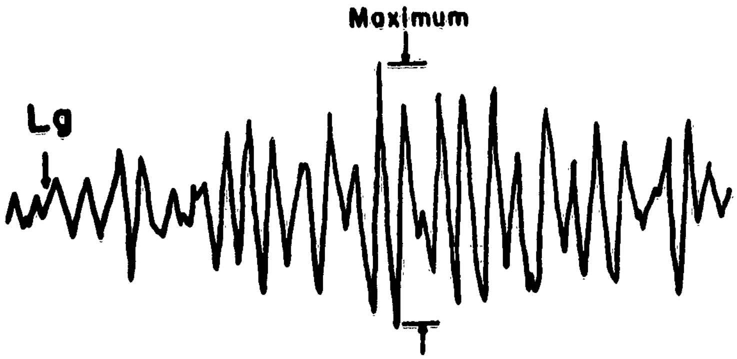
APPENDIX II





DETAIL SHOWING ALLOWANCE FOR LINE WIDTH





Pick <u>time</u> of <u>Pn</u> at beginning of "a" half cycle.

Pick <u>amplitude</u> of <u>Pn</u> as maximum "$d/2$" within 2 or 3 cycles of "c".

Pick <u>amplitudes</u> of <u>Pg</u> and <u>Lg</u> at maximum of corresponding motion.

FIRST MOTION CRITERIA

TECHNICAL WORKING GROUP II (TWG II)

Excerpt from Appendices to Hearings before the Special Subcommittee on Radiation and the Subcommittee on Research and Development of the Joint Committee on Atomic Energy; 86th Cong., 2d Sess.; April 19-22, 1960; on Technical Aspects of Detection and Inspection Controls of a Nuclear Weapons Test Ban; Part 2 of 2 Parts, pp. 632-633:

"2. Identification of Earthquakes

A located seismic event shall be ineligible for inspection if, and only if, it fulfills one or more of the following criteria:

a. Its depth of focus is established as below 60 kilometers;

b. Its epicentral location is established to be in the deep open ocean and the event is unaccompanied by a hydroacoustic signal consistent with the seismic epicenter and origin time;

c. It is established within 48 hours to be a foreshock by the occurrence of a larger event of at least magnitude 6 whose epicenter coincides with that of the given event within the accuracy of the determination of the two epicenters. The eligibility of the second event for inspection must be determined separately.

d. The directions of clearly recorded first motions define a pattern which strongly indicates a faulting source. First motions recorded at distances between 1100 kilometers and 2500 kilometers will not be used. First motions beyond 3500 kilometers will not be used for events of magnitude smaller than 5.5. The apparent direction of first motion must also meet both the following minimum conditions to be considered to be clearly recorded:

(1) The amplitude of the half-cycle of apparent first motion is at least two (2) times as large as any half-cycle of apparent noise in the preceding few minutes, and

(2) The largest of the amplitudes of the half-cycle of apparent first motion and the two immediately following half-cycles:

(a) at epicentral distances less than 700 kilometers is twenty (20) times larger than any half-cycle of noise in the preceding few minutes;

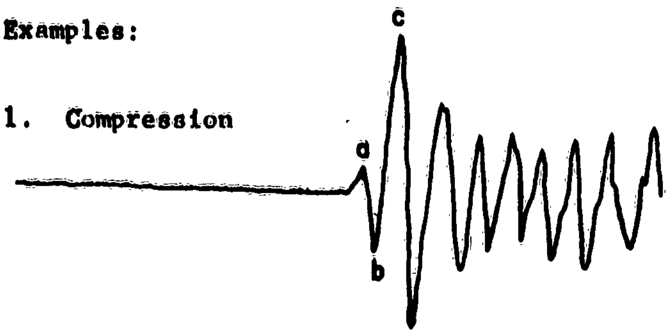
(b) at epicentral distances more than 700 kilometers is forty (40) times larger than any half-cycle of noise in the preceding few minutes.

A pattern of clearly recorded first motions strongly indicates a faulting source if the observed motions, extended backward to a small sphere about the focus, can be separated into alternate quadrants by two orthogonal great circles drawn on the small sphere, with the requirement that two opposite quadrants combined (i) contain at least 4 clearly recorded rarefactive first motions and (ii) contain not more than 15% compressions among the clearly recorded first motions."

Application of the TWG II Criteria

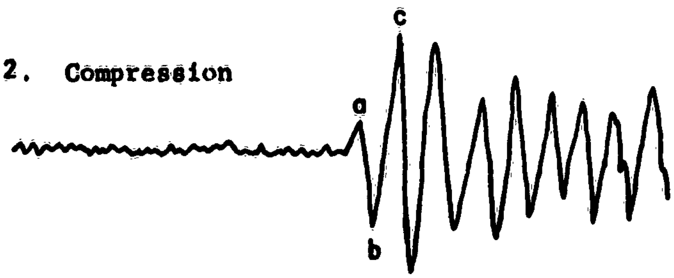
Examples:

1. Compression



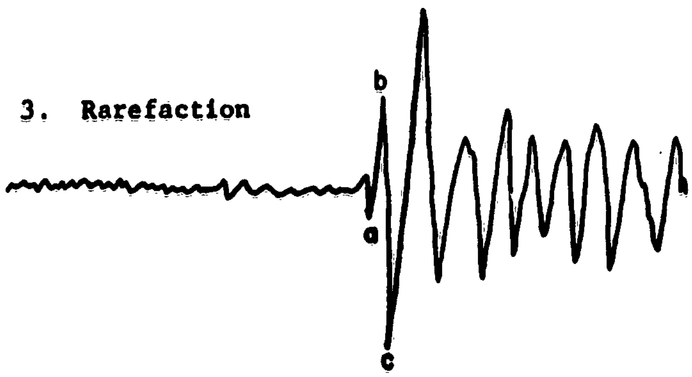
$700 < \Delta < 1100$ Km

2. Compression



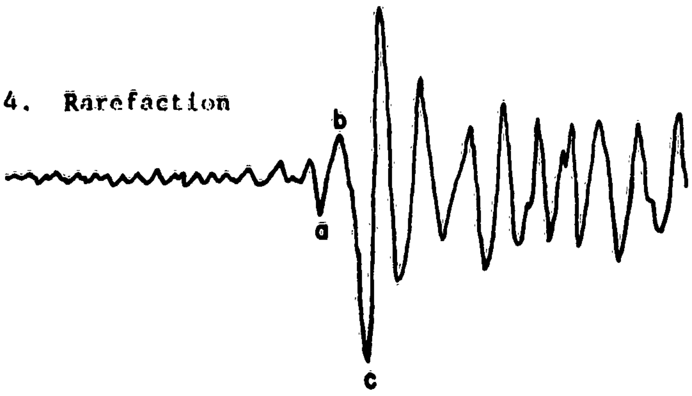
$\Delta < 700$ Km

3. Rarefaction



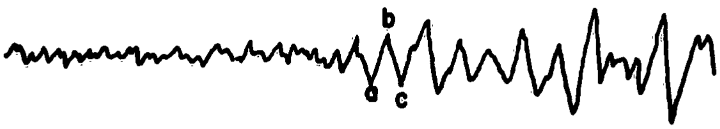
$\Delta < 700$ Km. Example shows what may be interpreted to be earlier signal; however, motion is less than 2 times the noise level and may be interpreted as noise.

4. Rarefaction

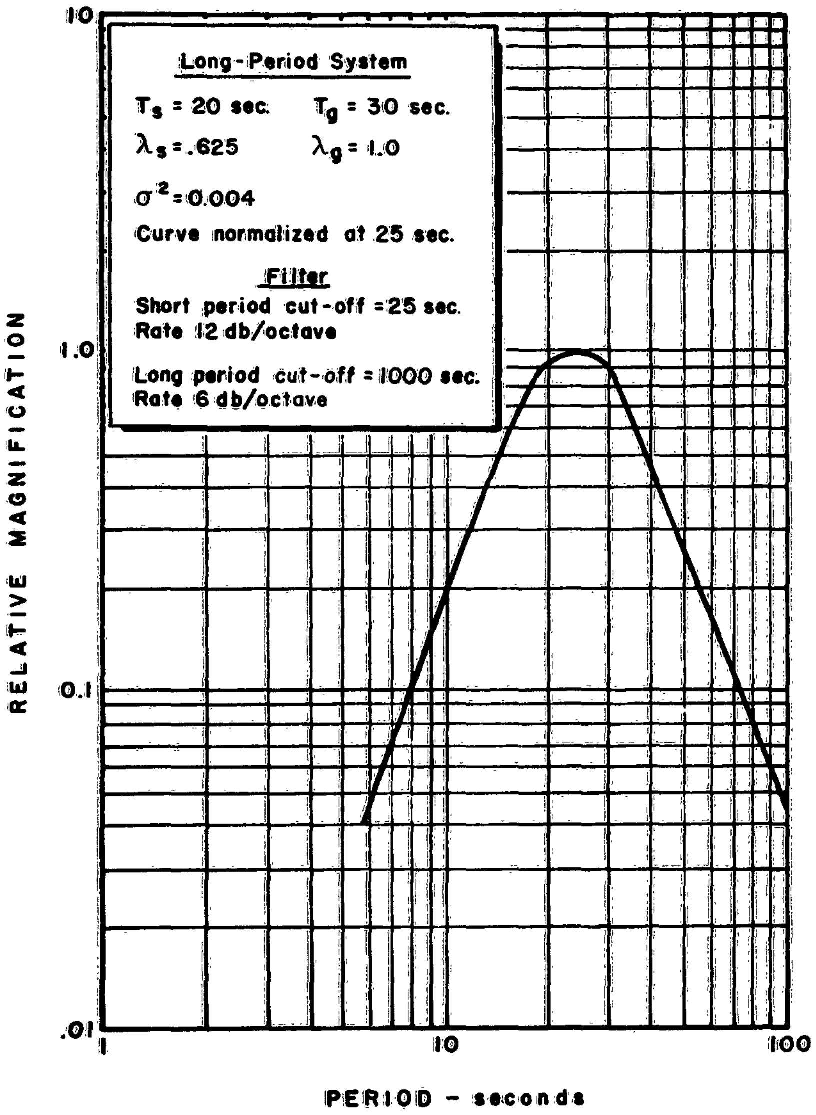


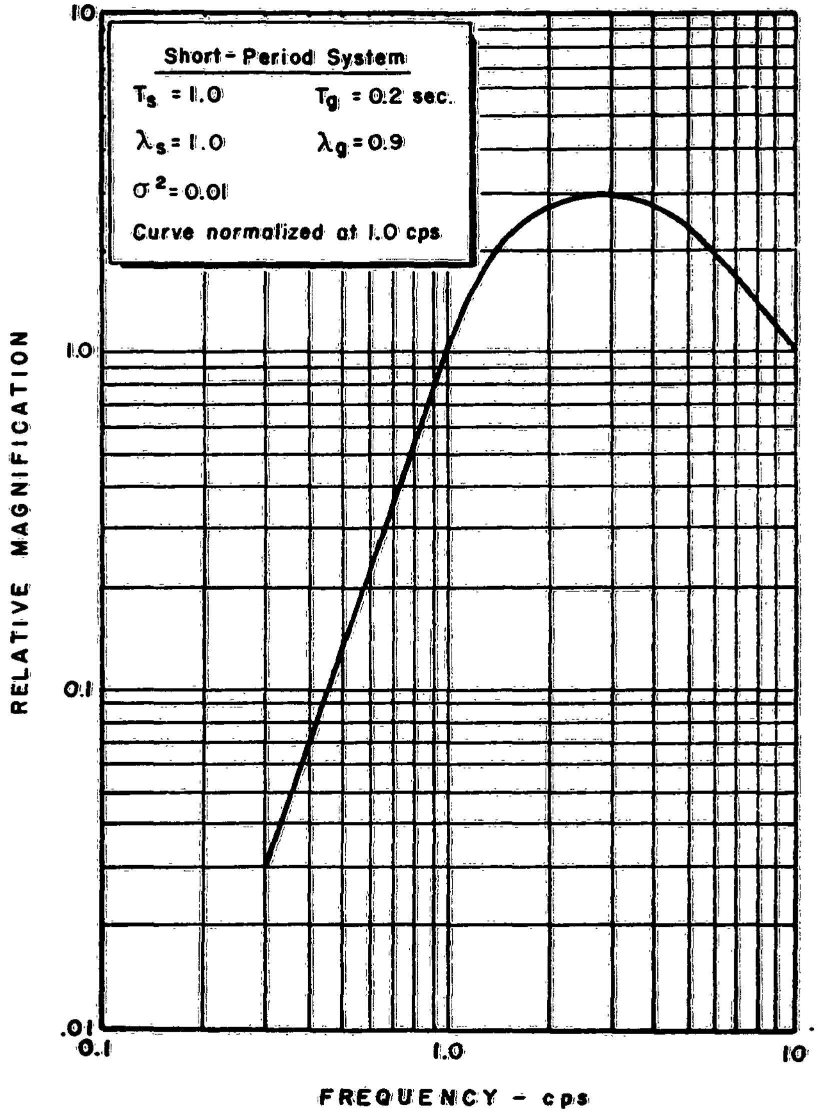
Δ < 700 Km
Similar to example 3.

5. Not applicable



Δ < 700 Km. Amplitude of first 3 half-cycles is less than 20 times noise.





LP and SP Response Curves

1

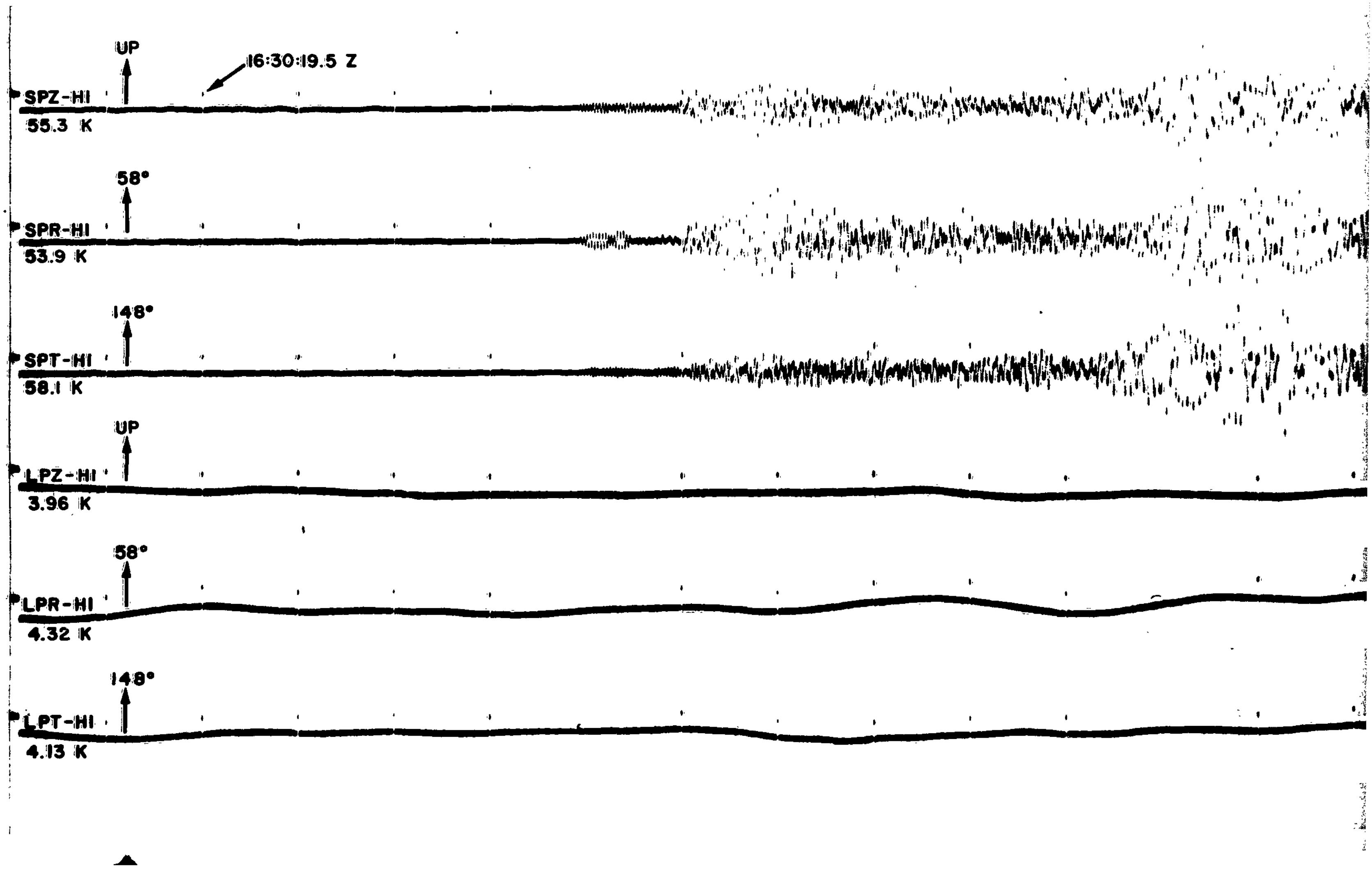
STOAT

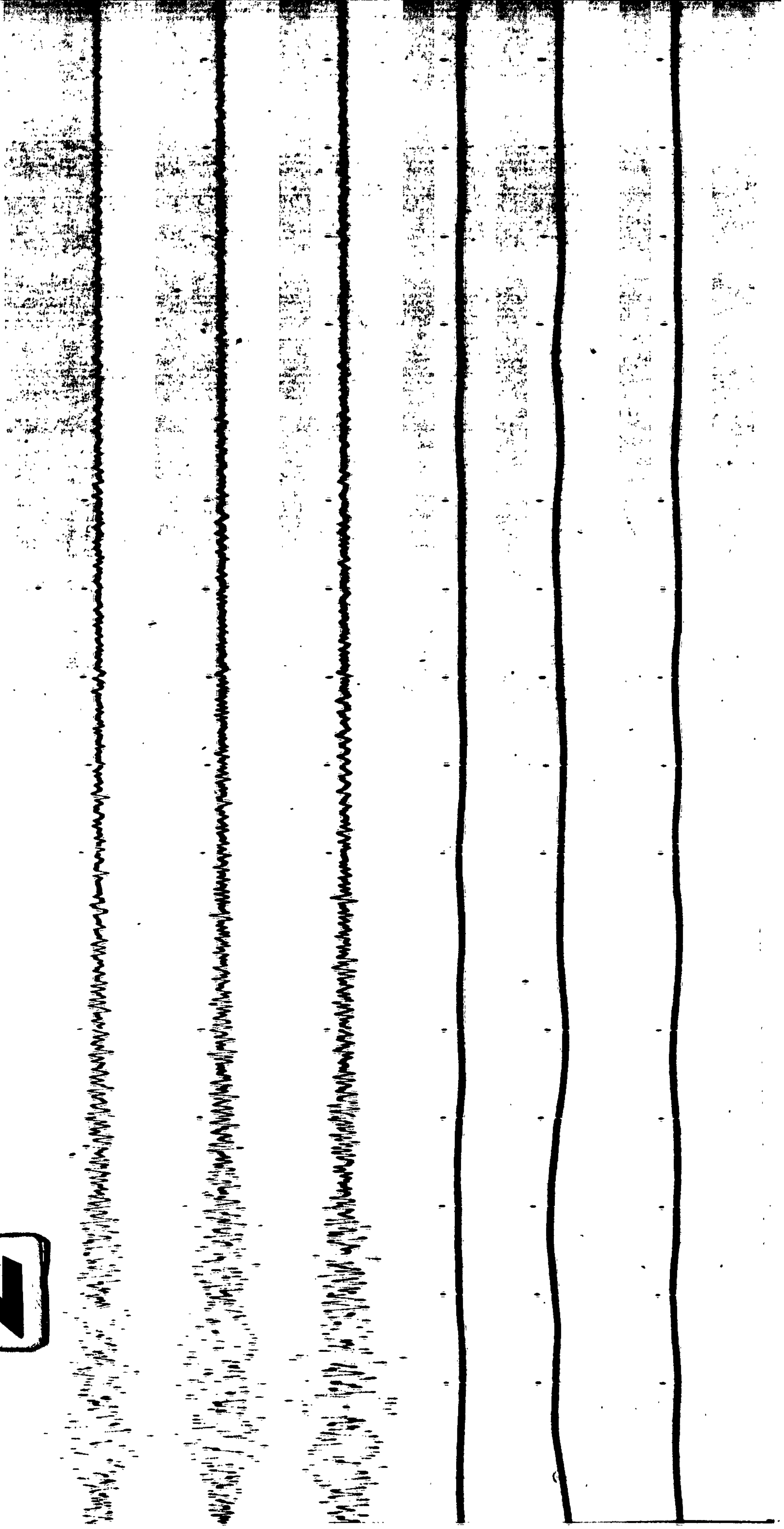
FM UT

Fillmore, Utah

9 January 1962

Δ=413 km





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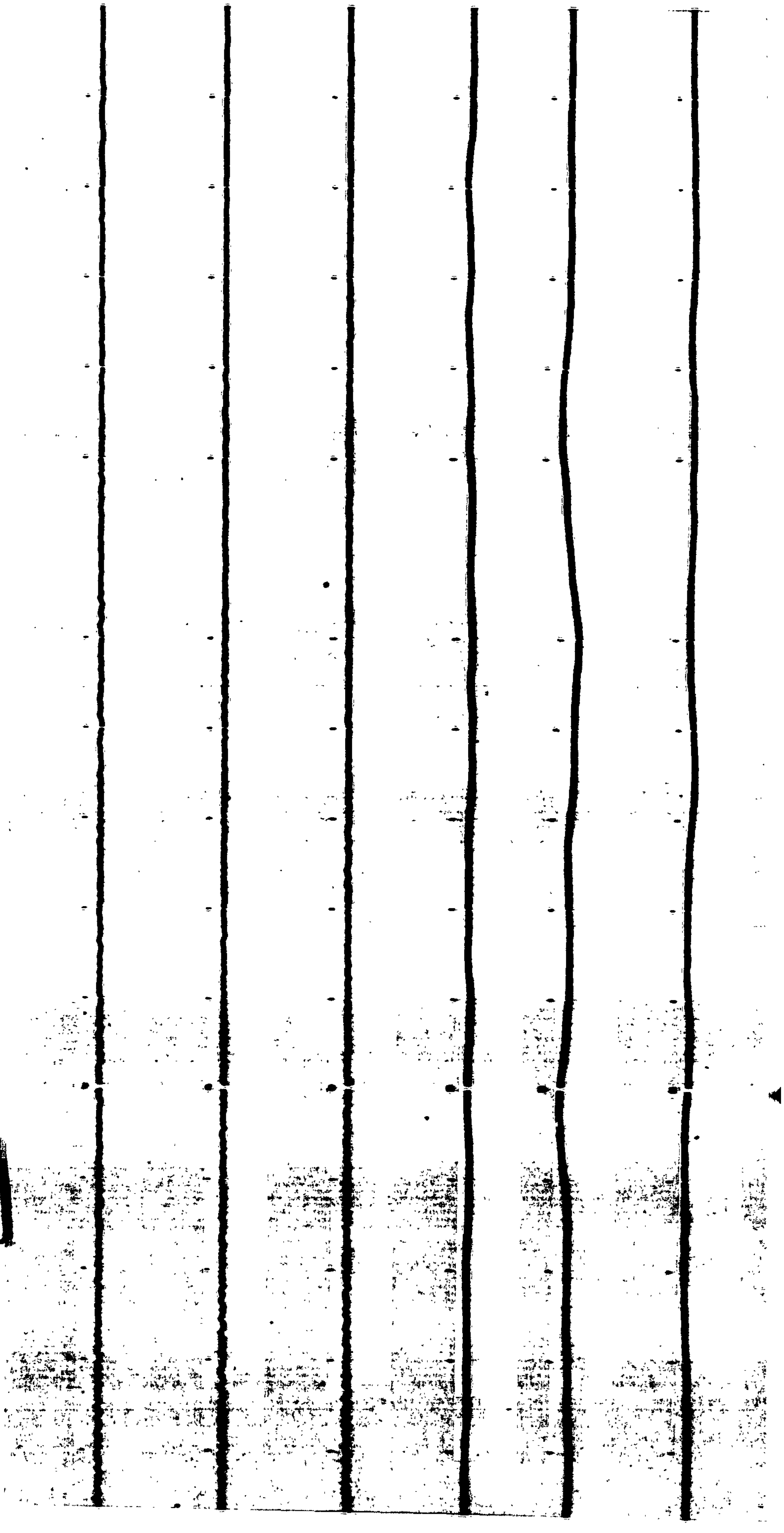
3



1

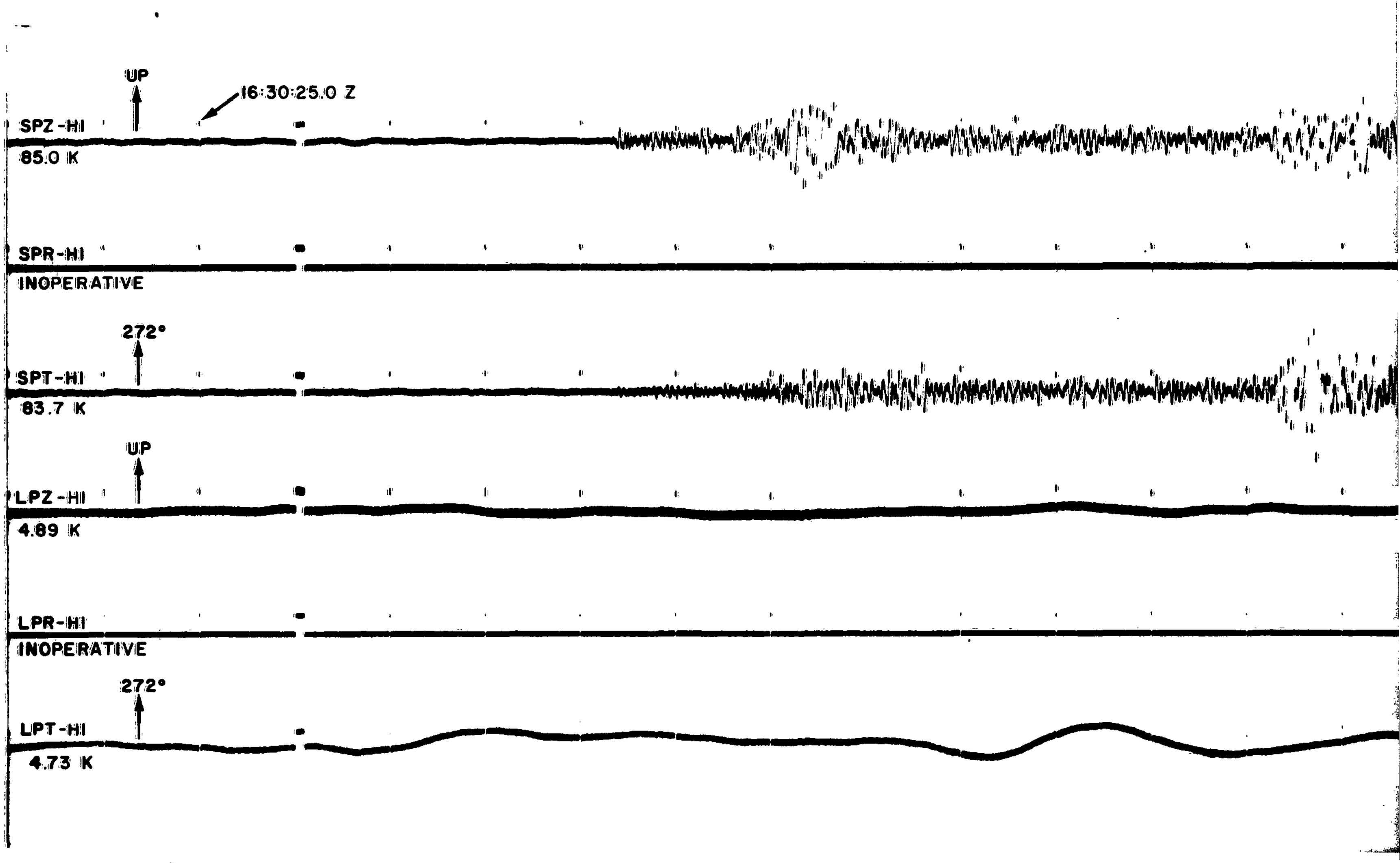
STOAT

CP CL

Campo, California

9 January 1962

Δ = 480 km



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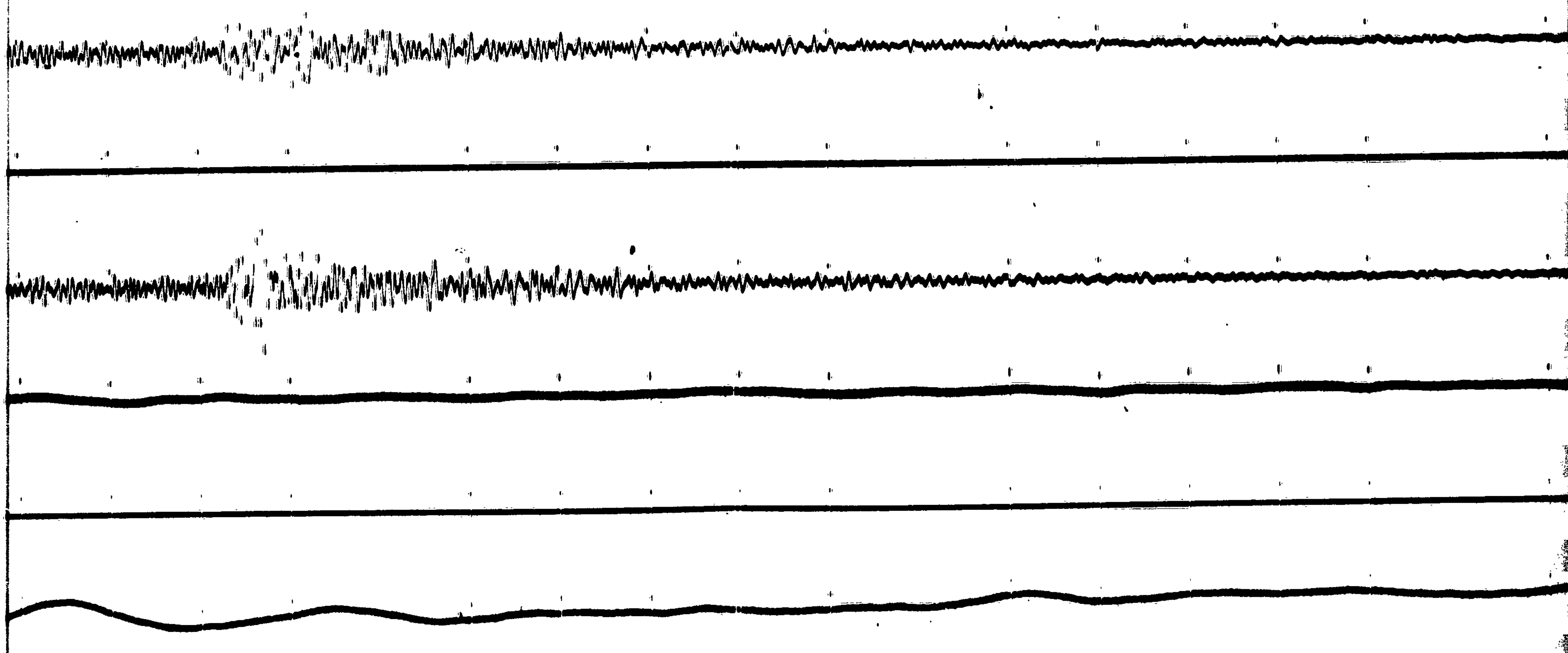

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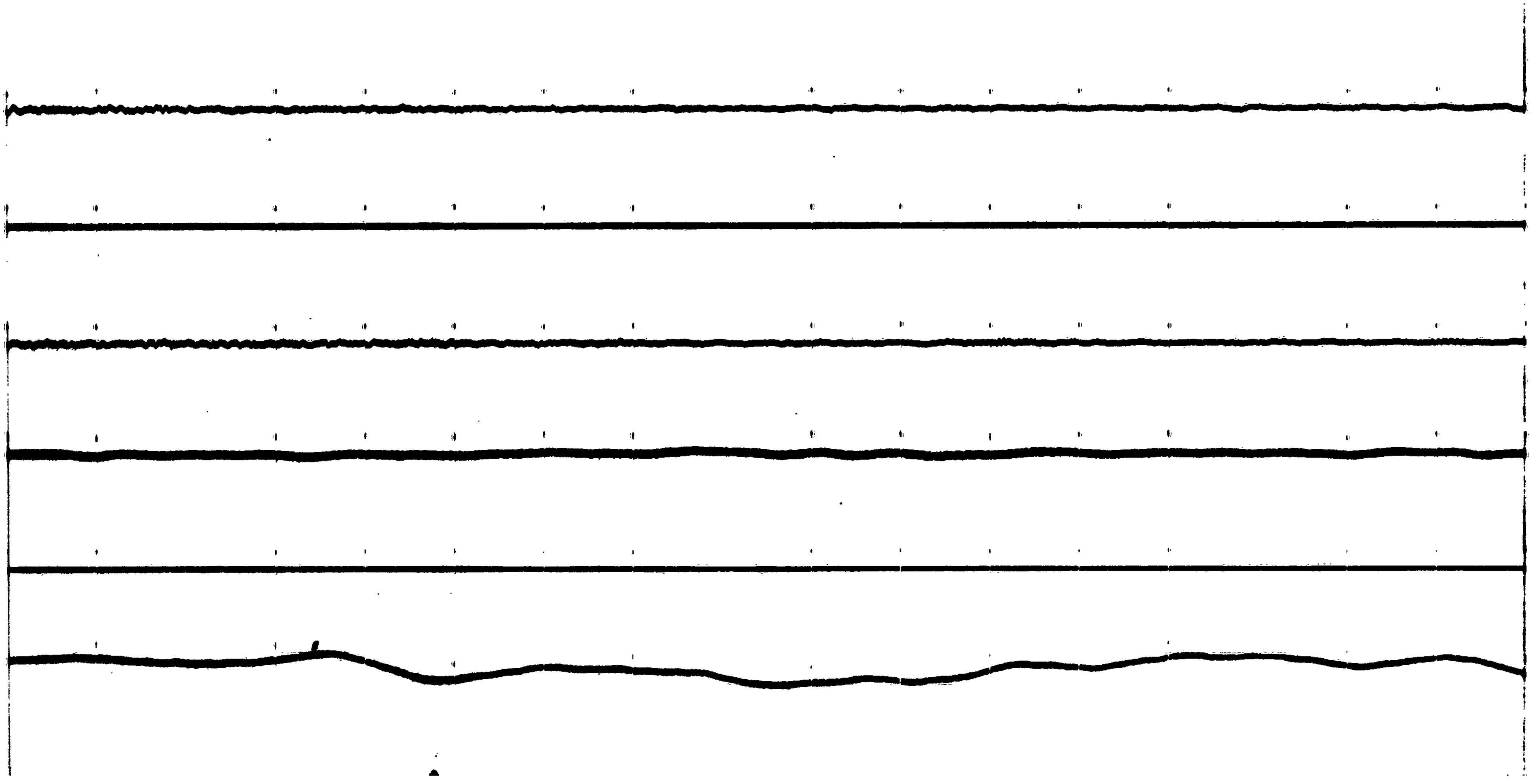


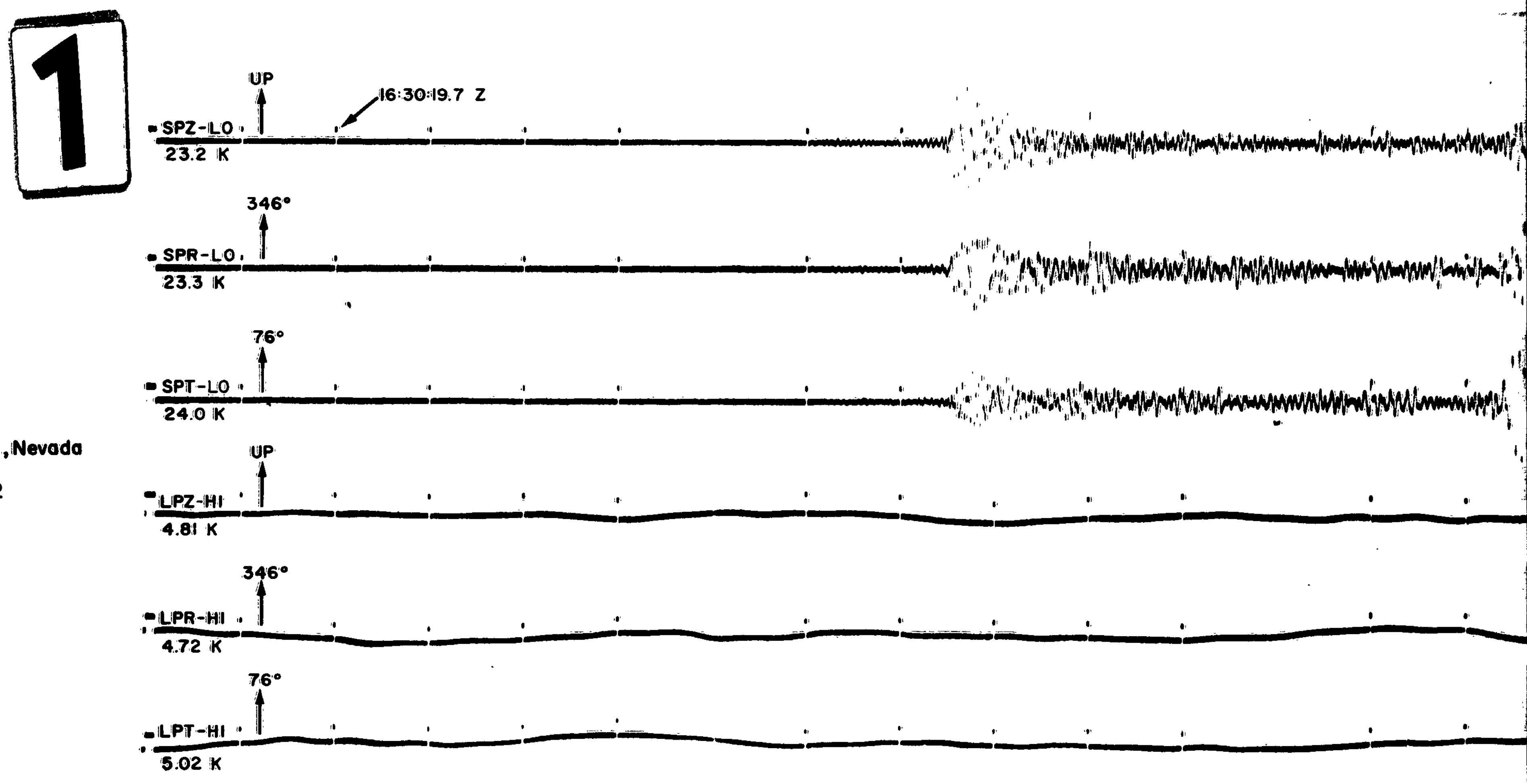
STOAT

WI NV

Winnemucca, Nevada

9 June 1962

Δ=494 km



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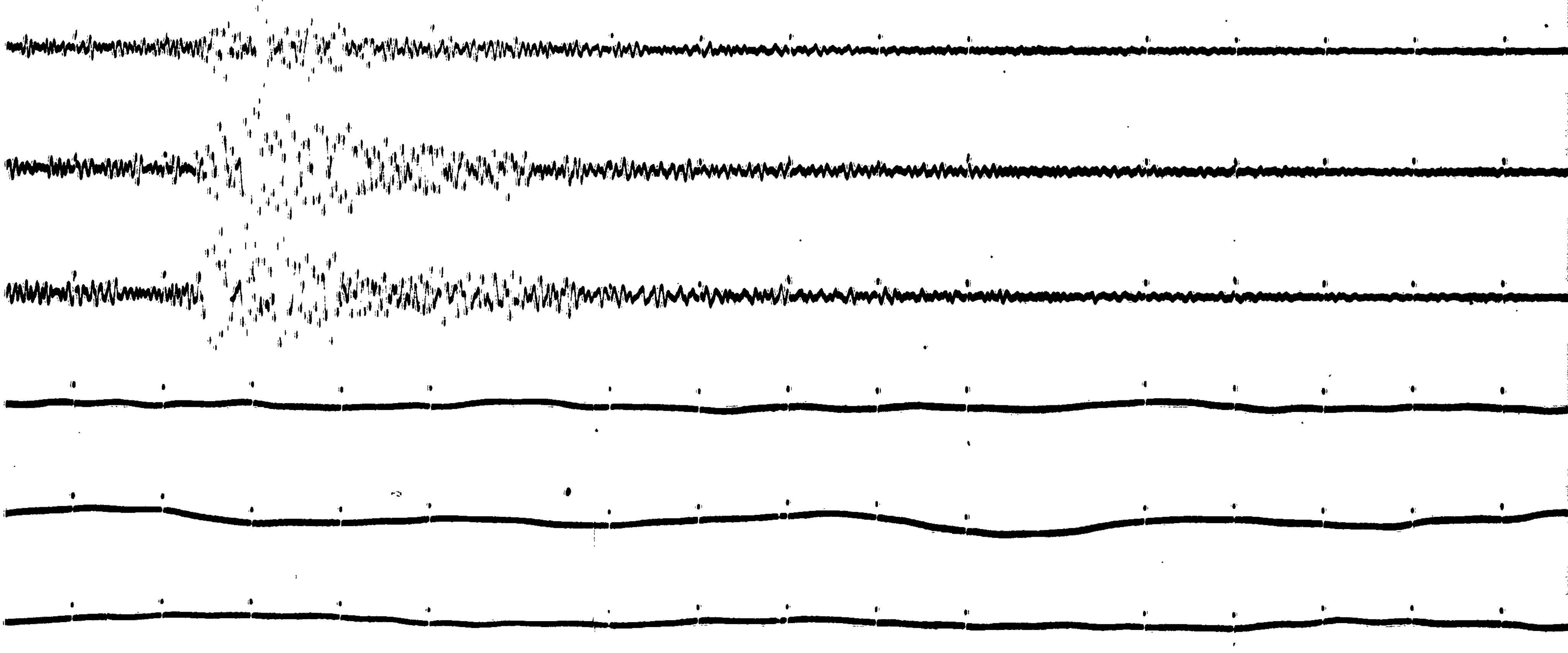
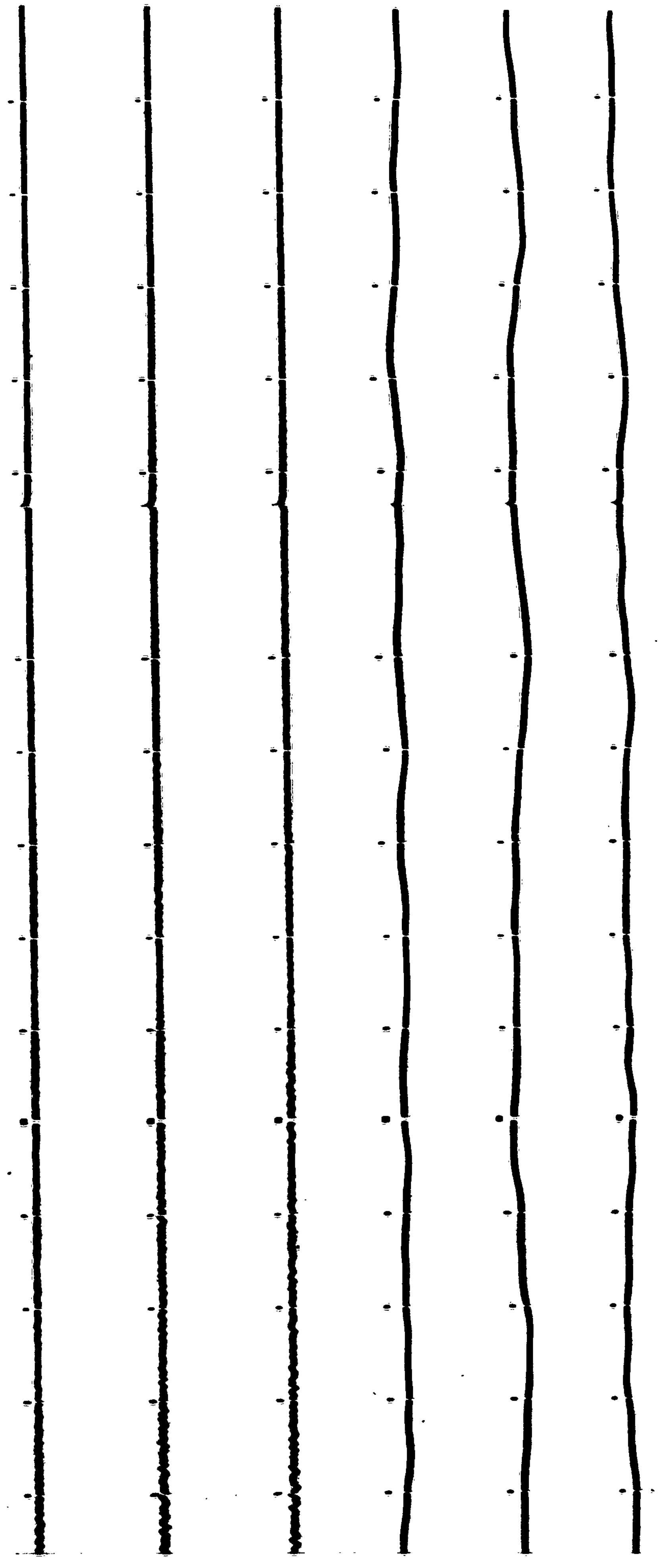




3

STOAT

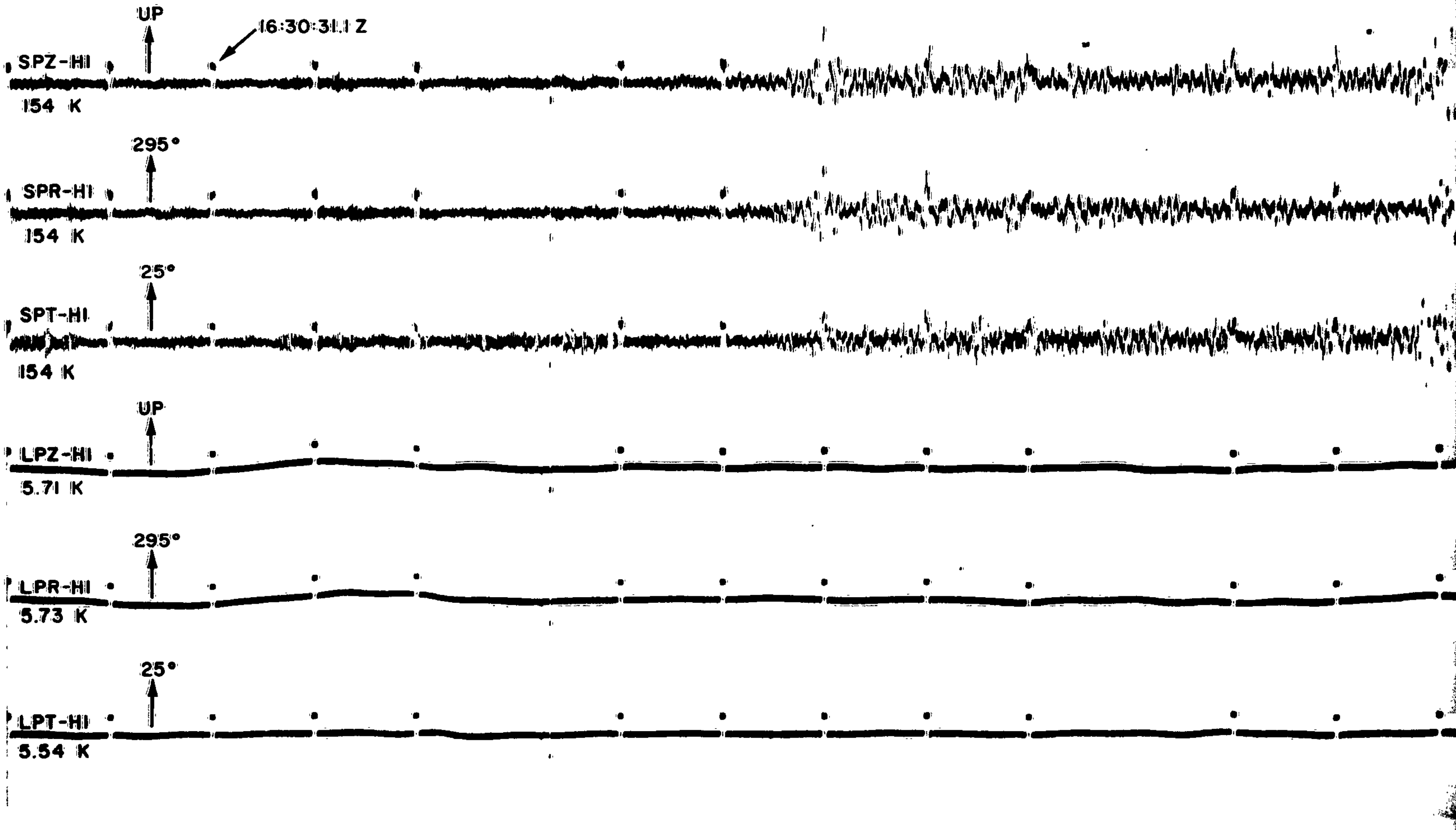
MV CL

Marysville, California

9 June 1962

Δ=521 km

1



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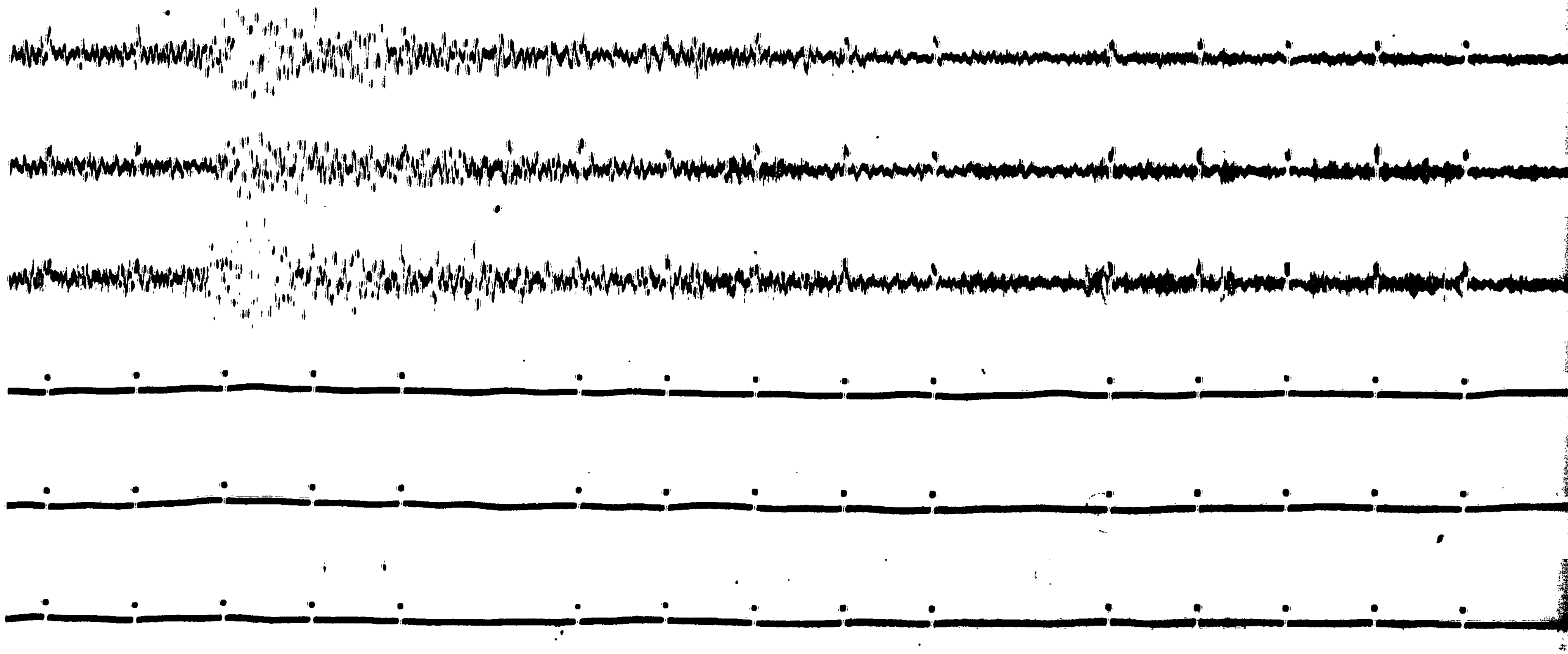

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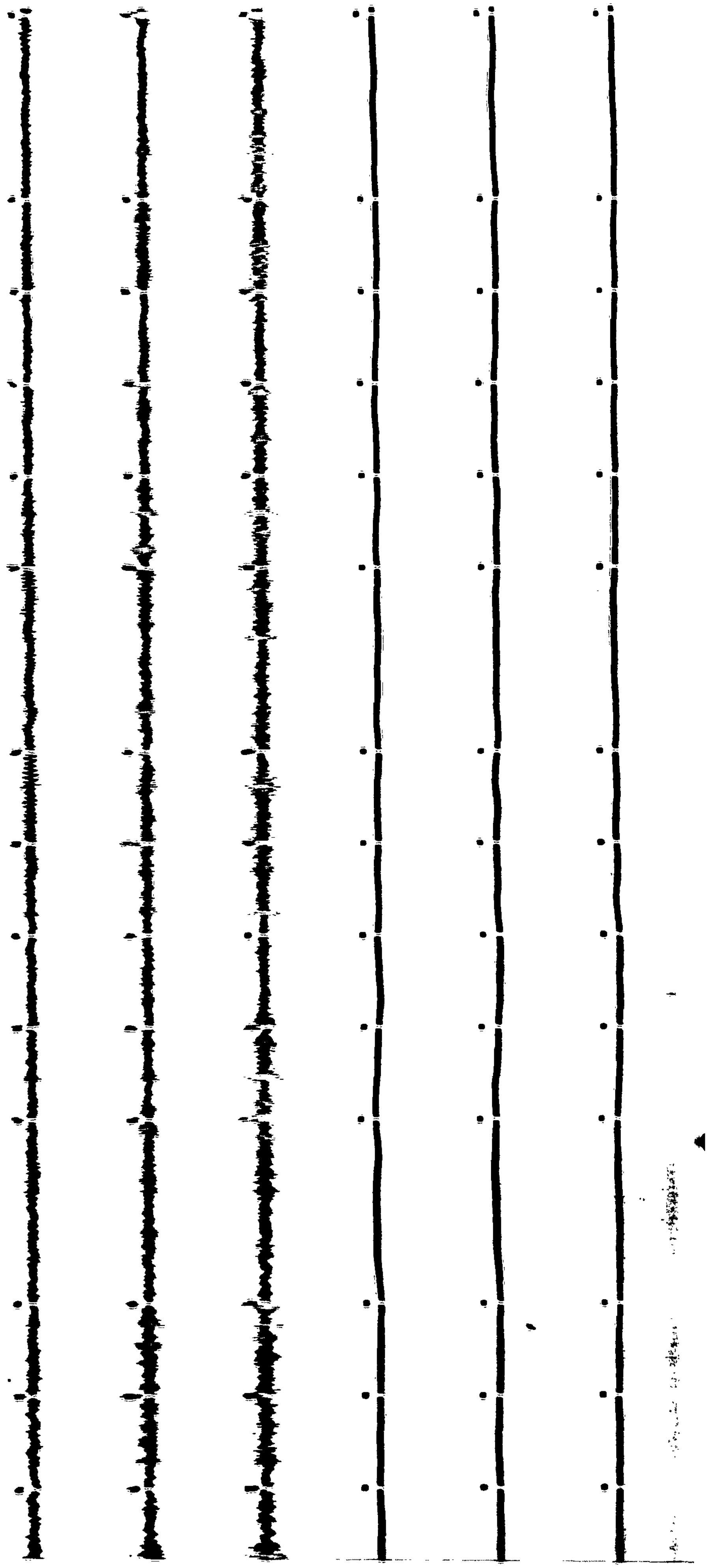


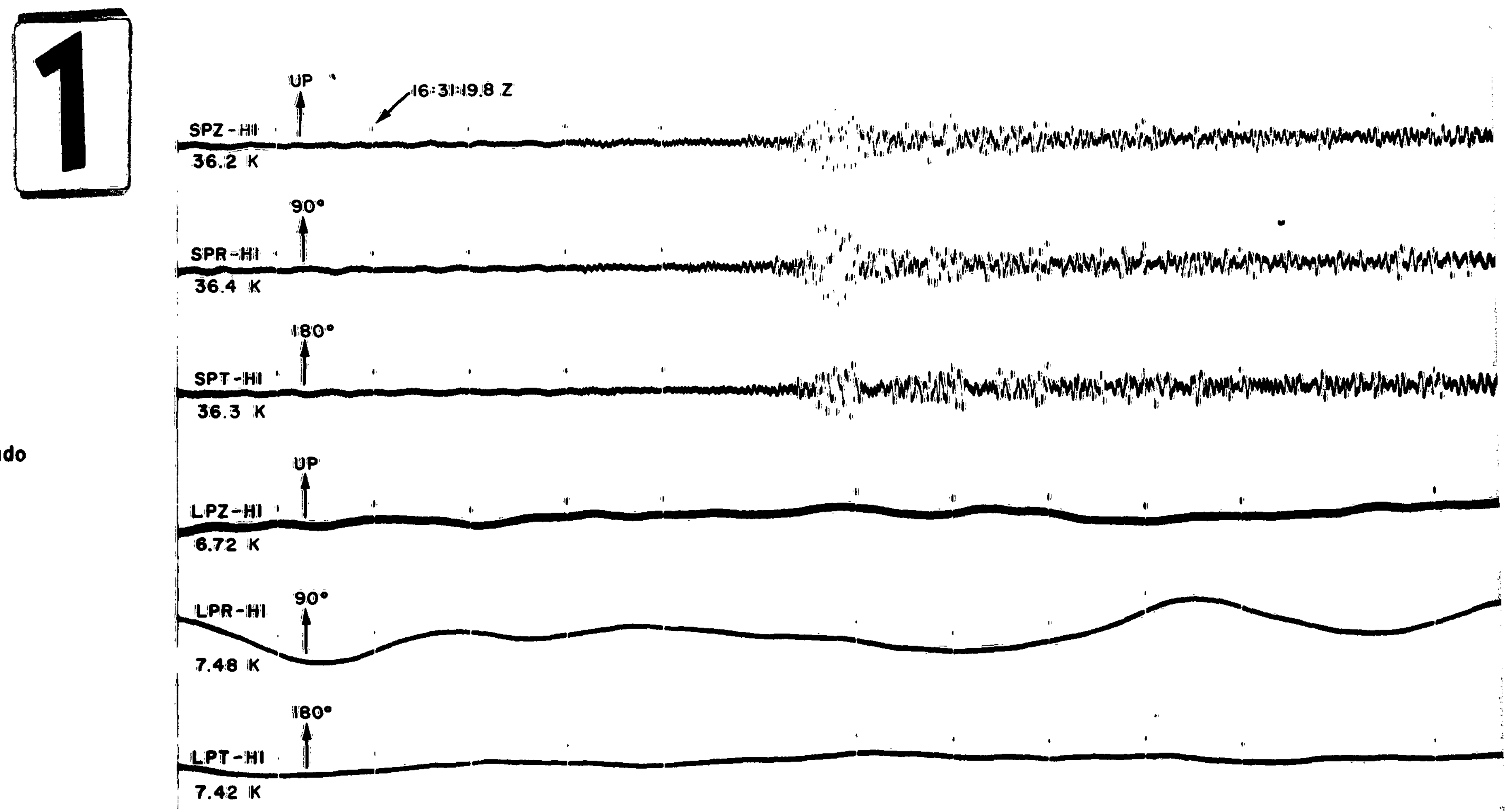
STOAT

DR CO

Durango, Colorado

9 January 1962

Δ=733 km



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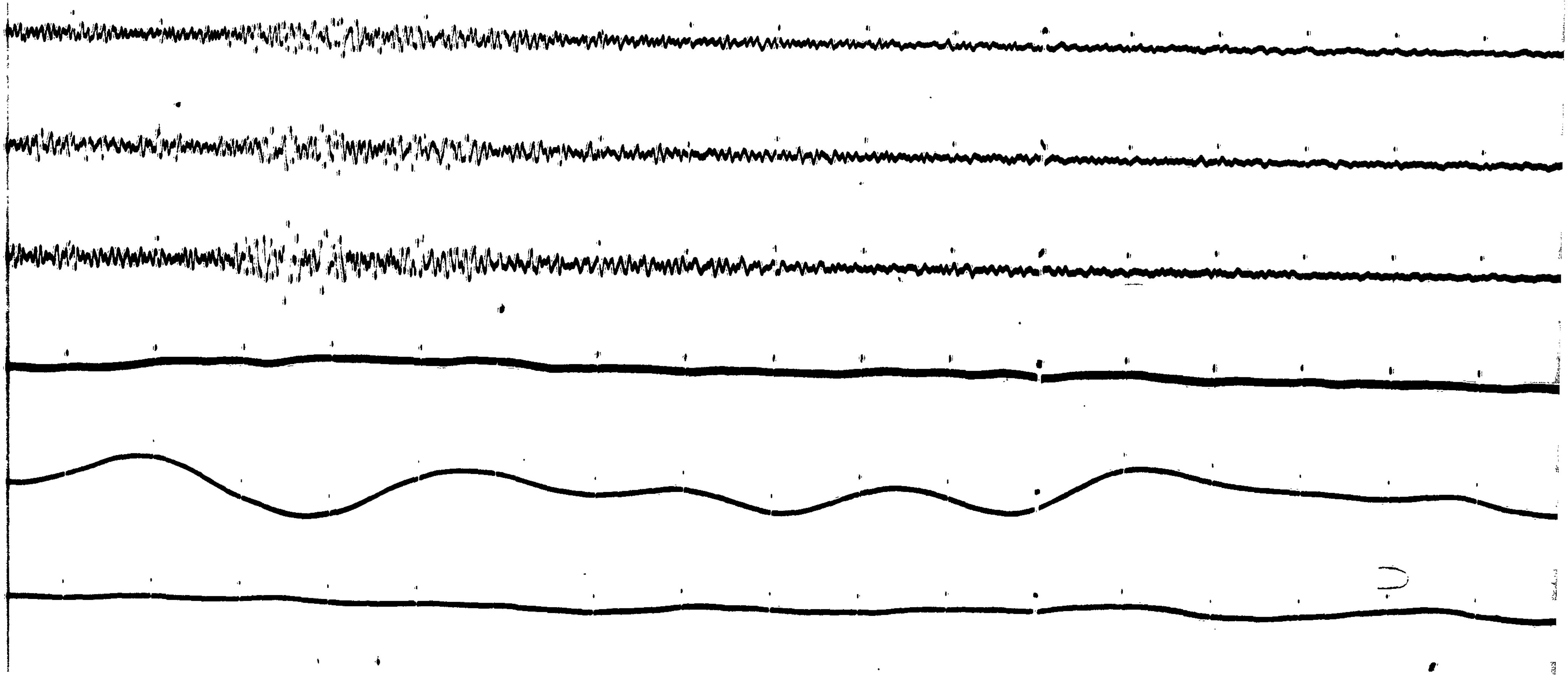

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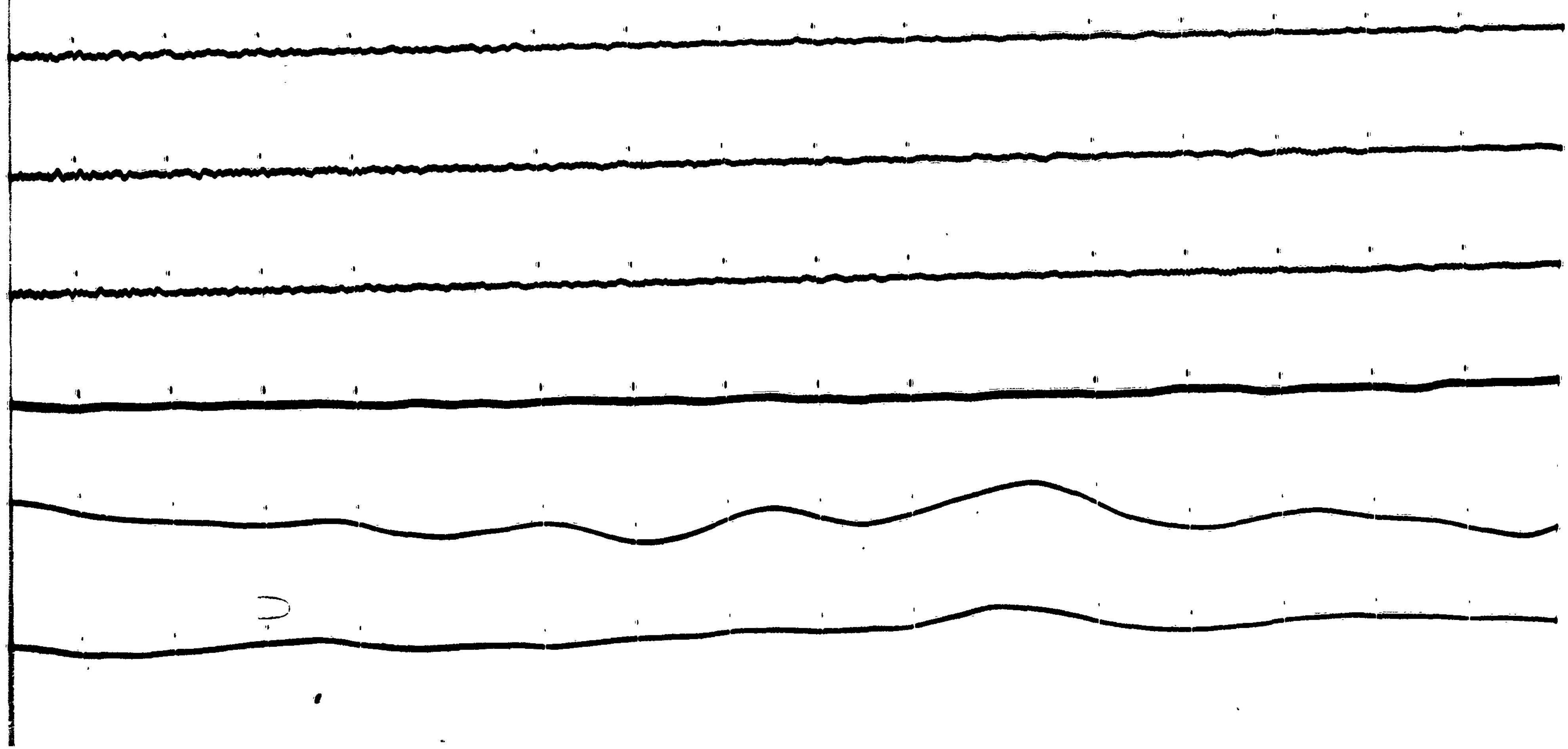


1

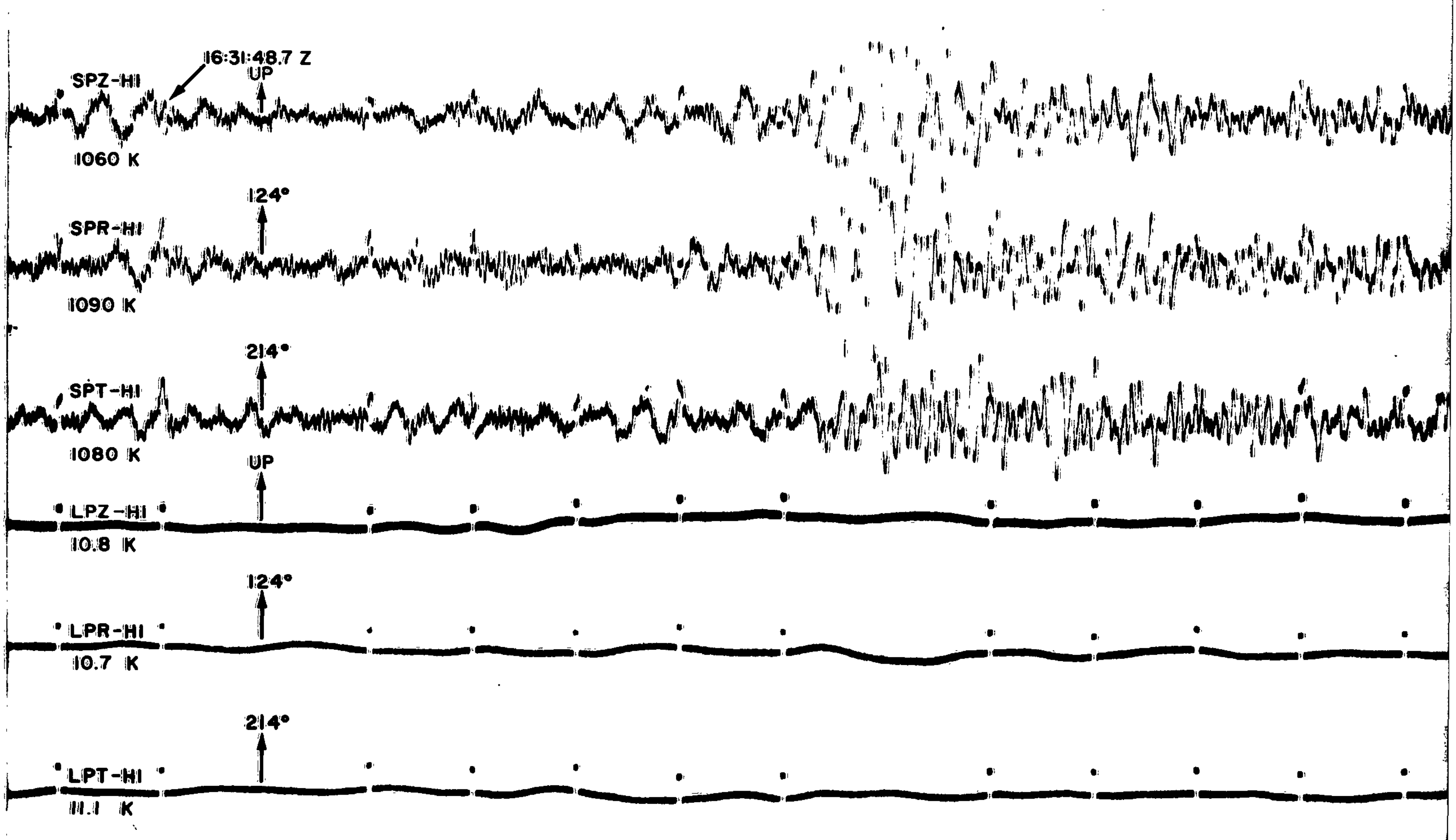
STOAT

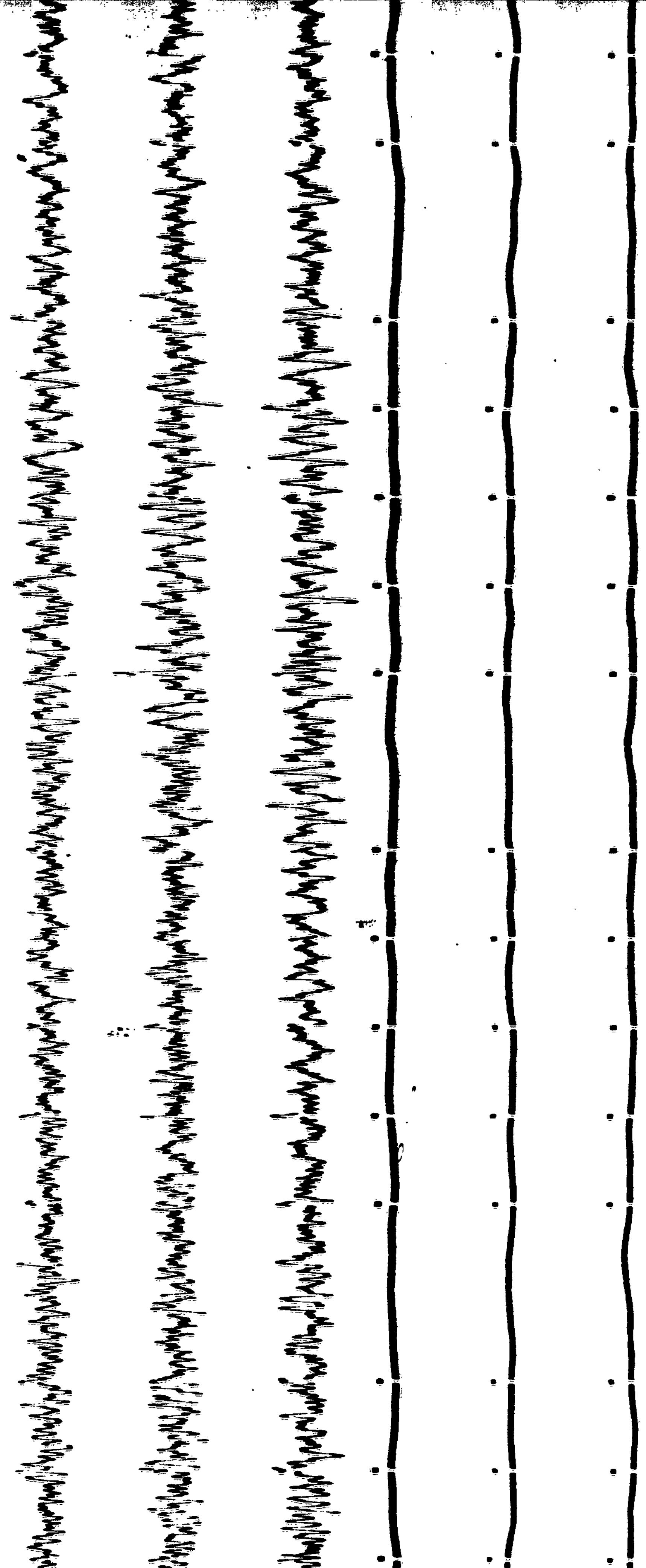
LC NM

Las Cruces, New Mexico

9 January 1962

Δ=1005 km





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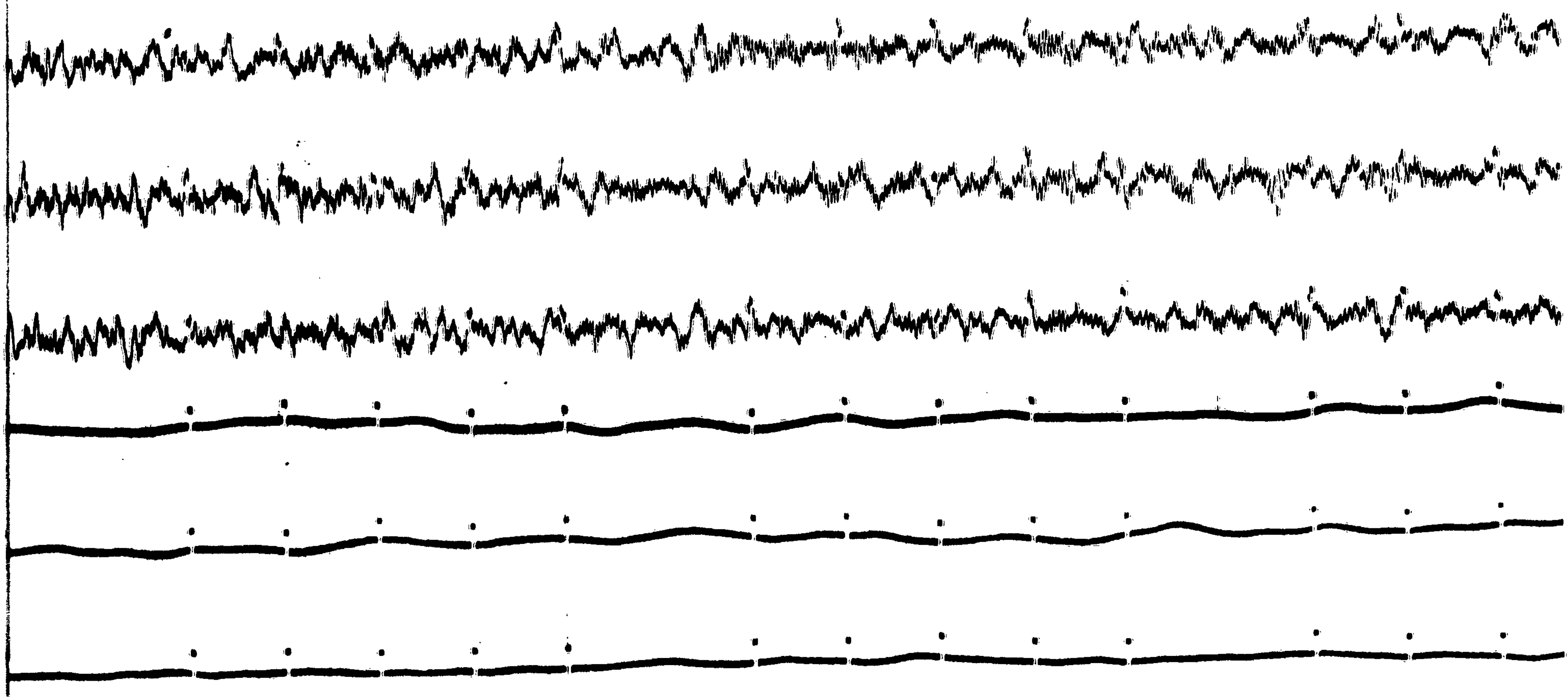


STOAT (COLLAPSE)

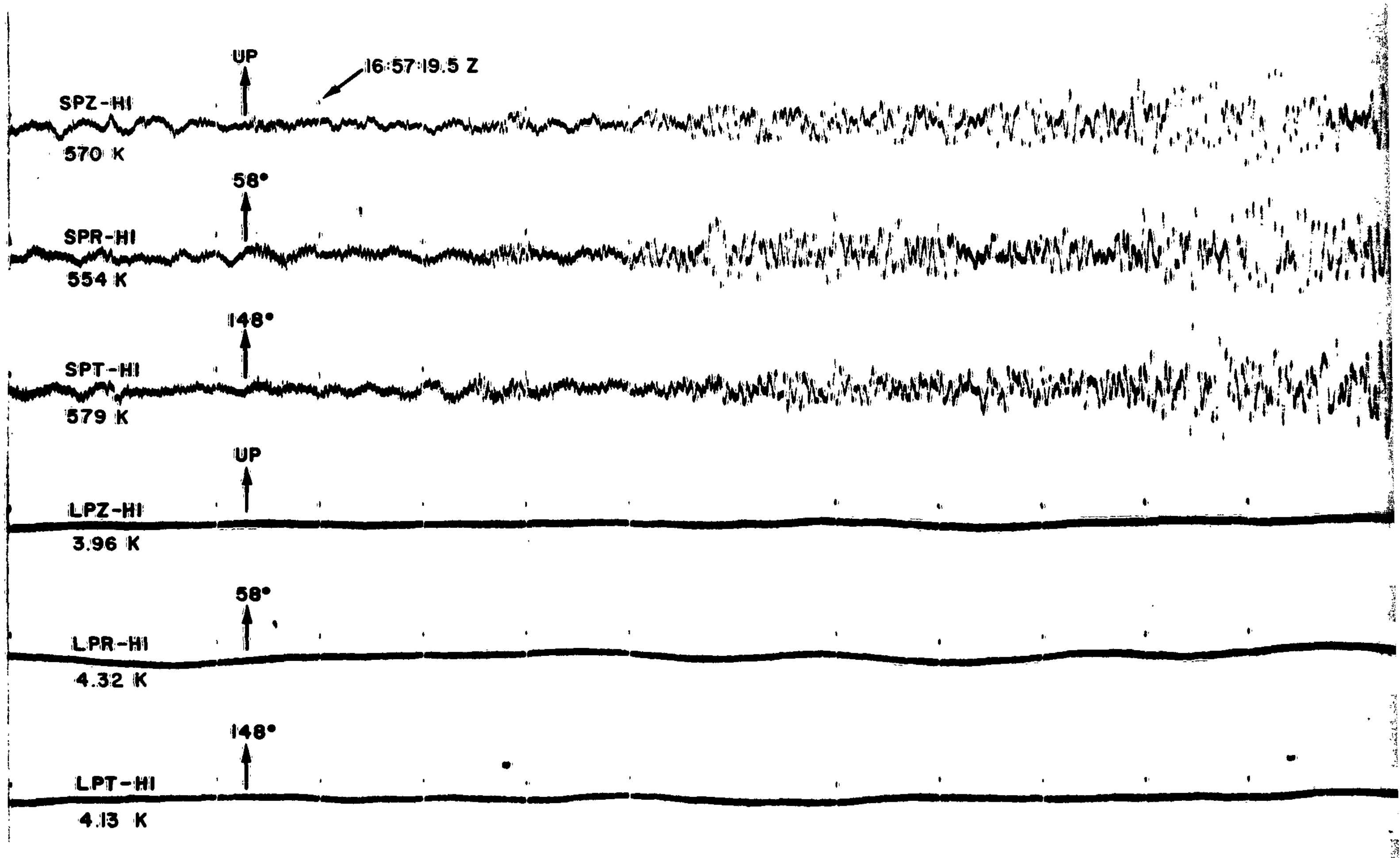
FM UT

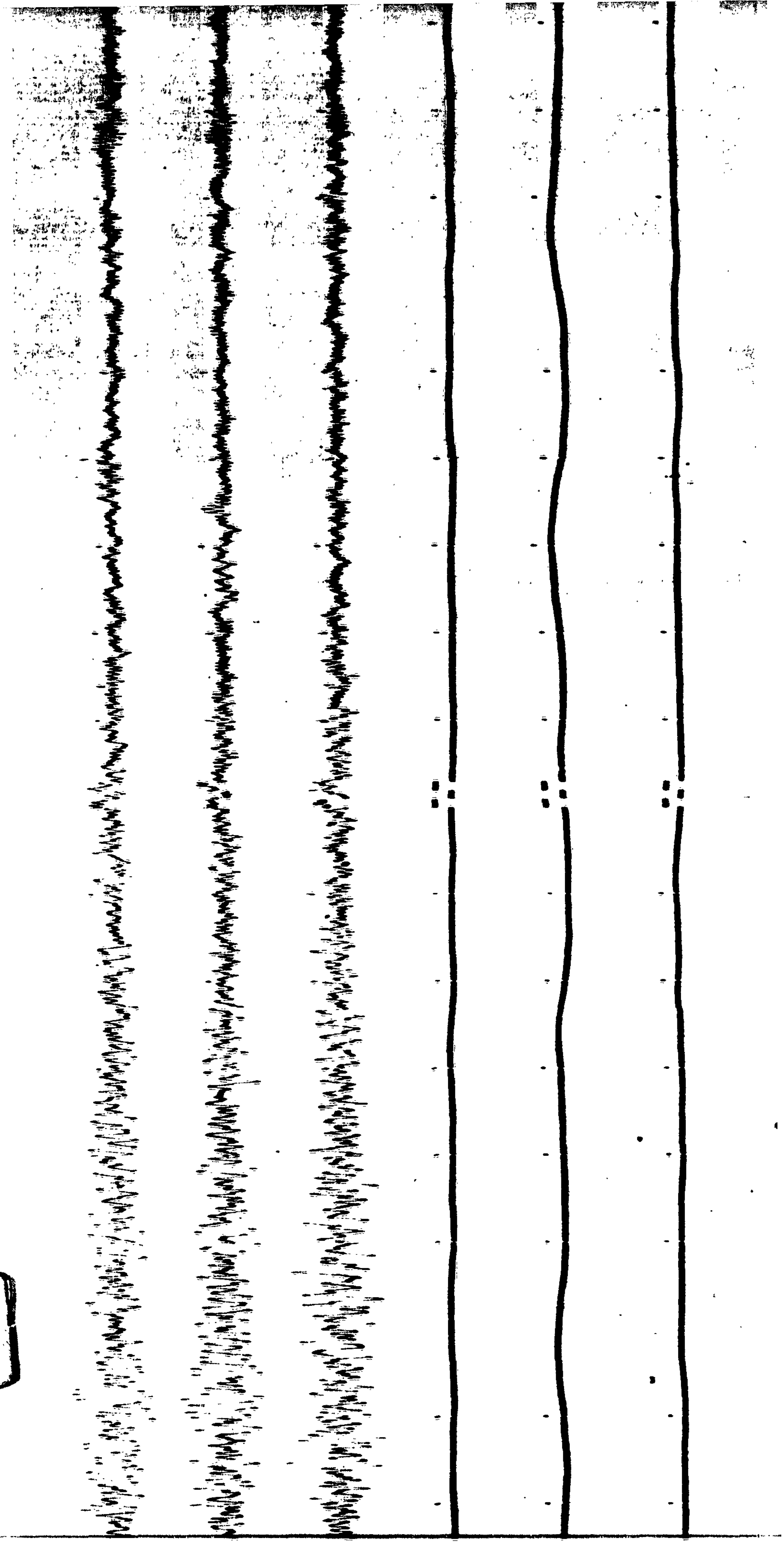
Fillmore, Utah

9 January 1962

Δ=413 km

1





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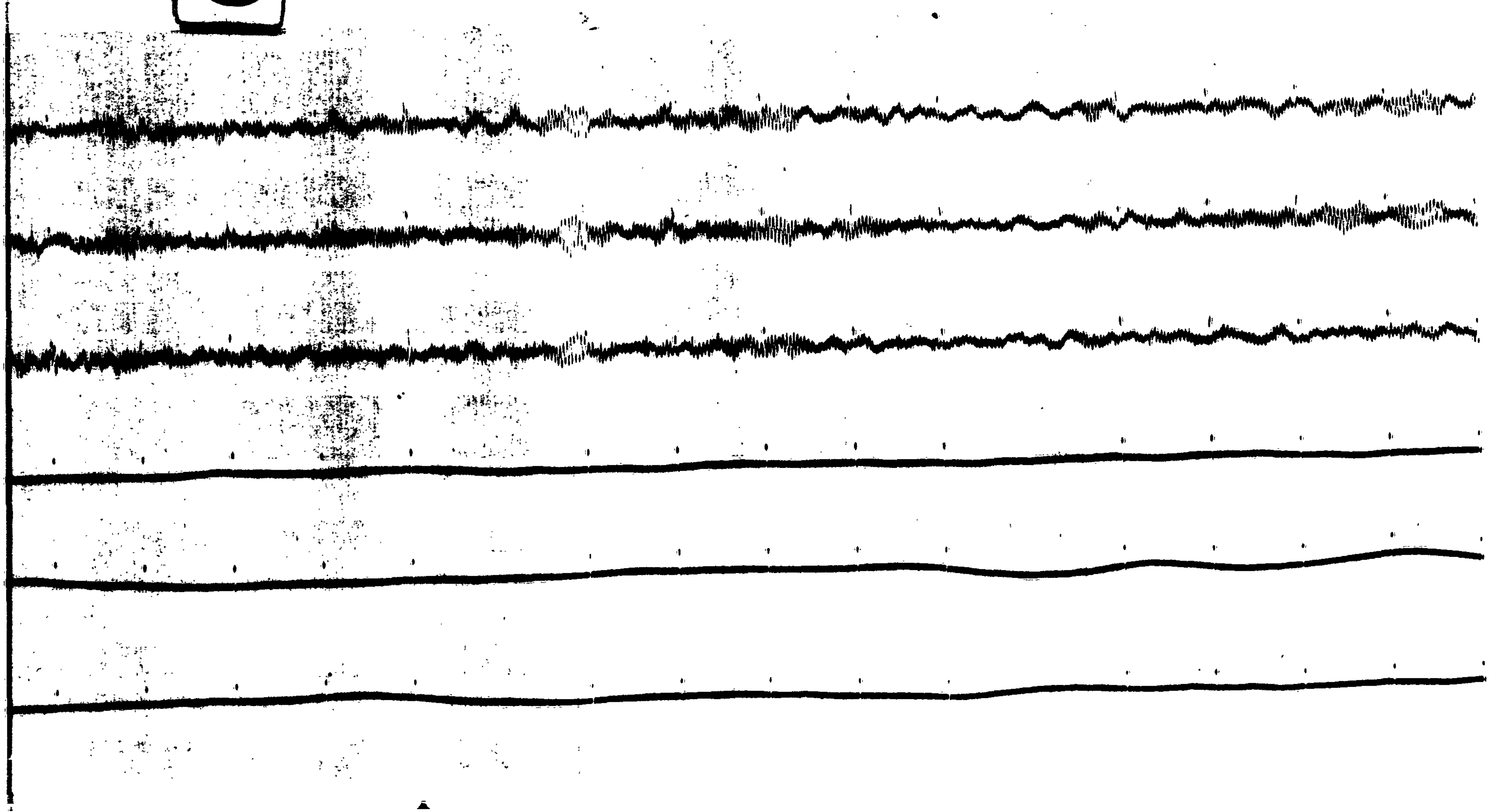
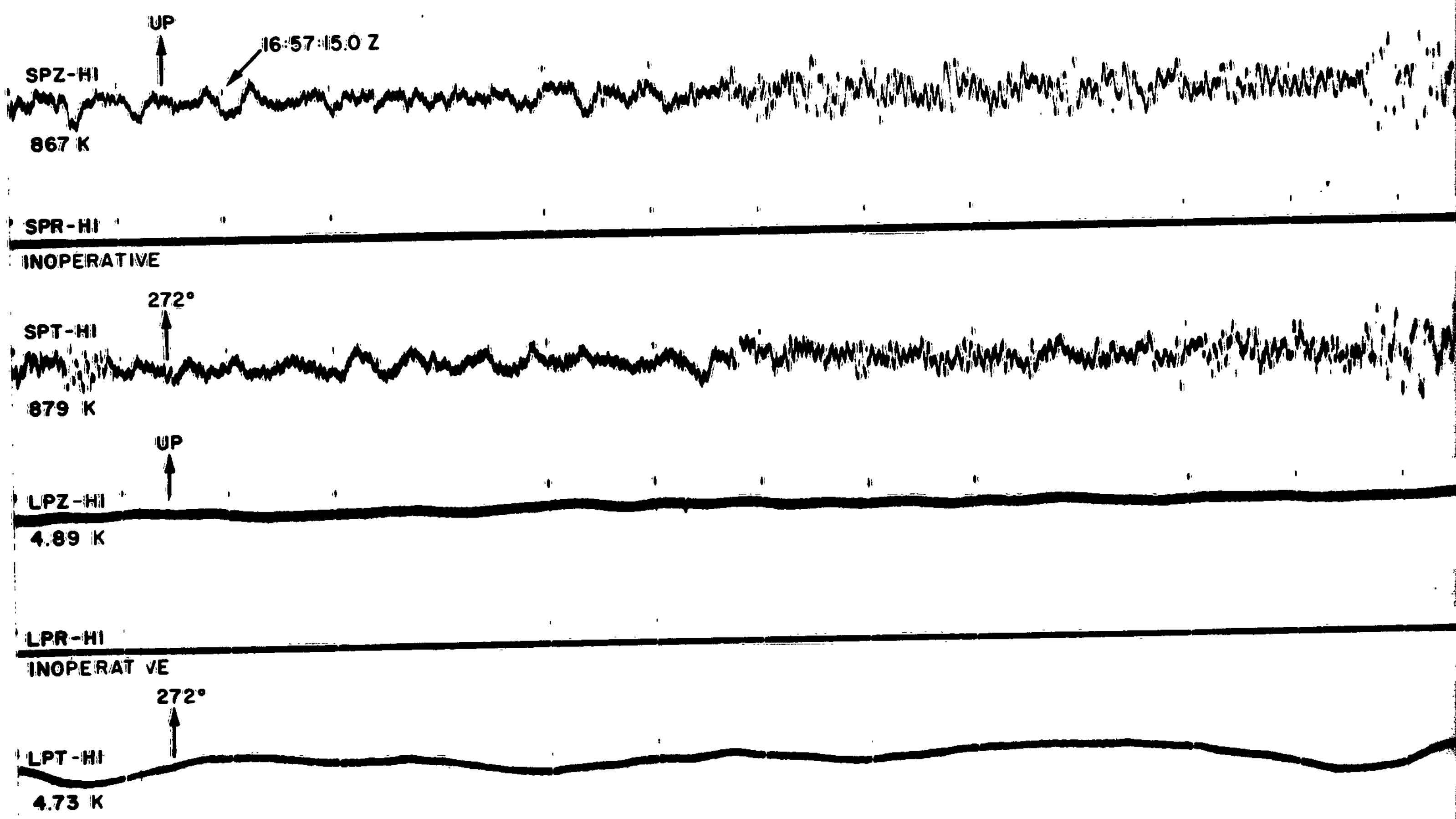


1



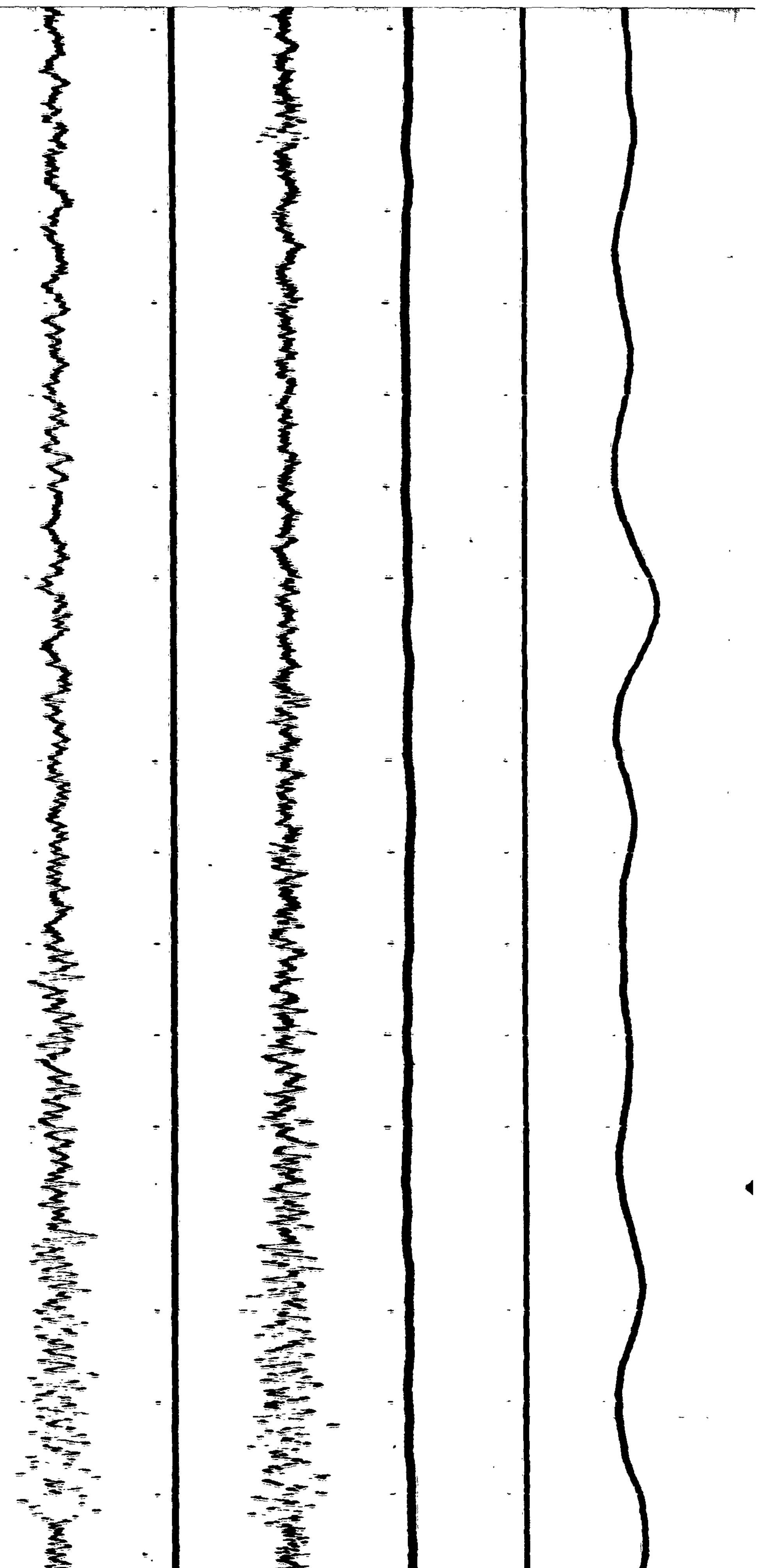
STOAT (COLLAPSE)

CP CL

Campo, California

9 January 1962

Δ=480 km



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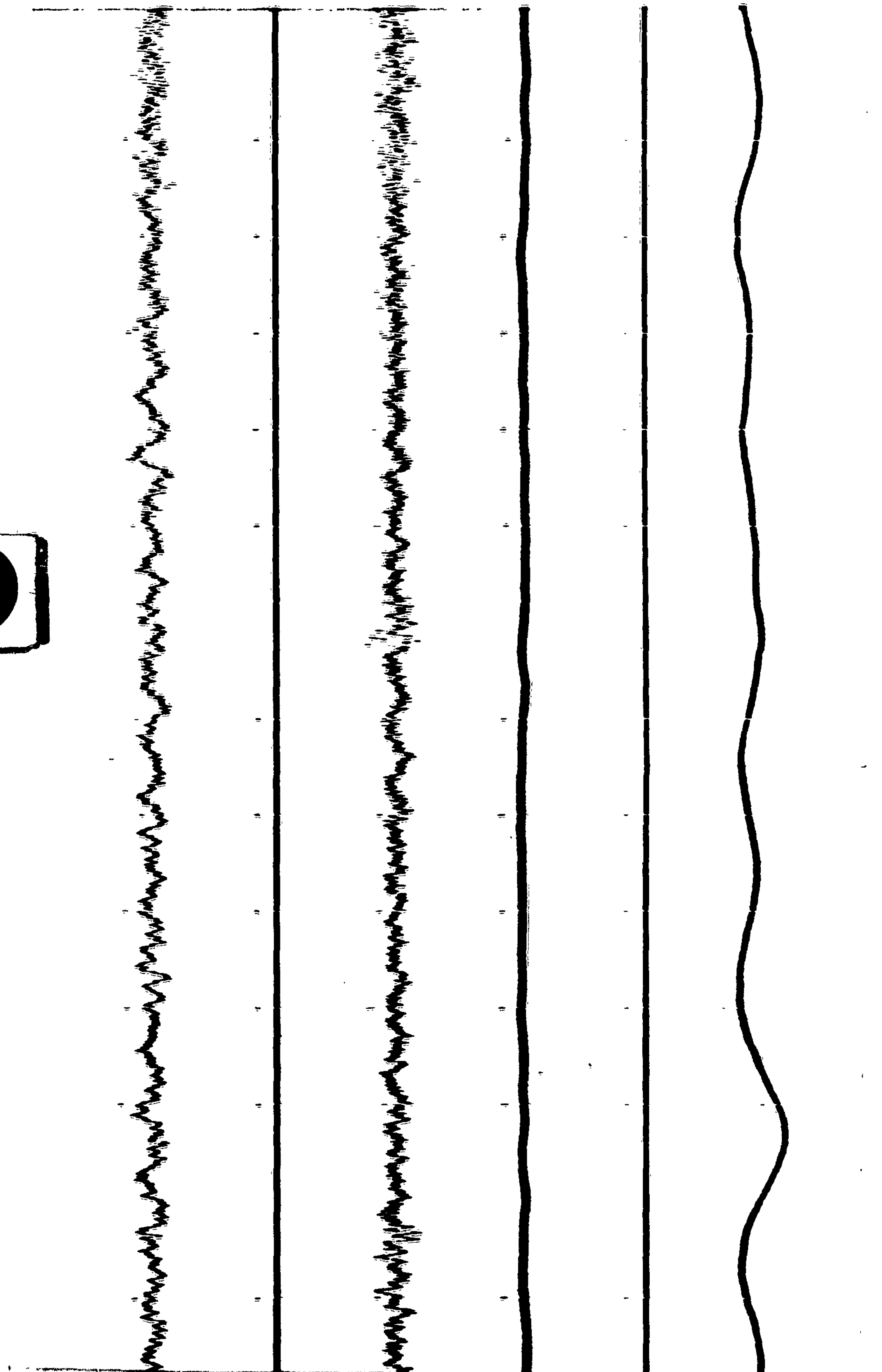
3



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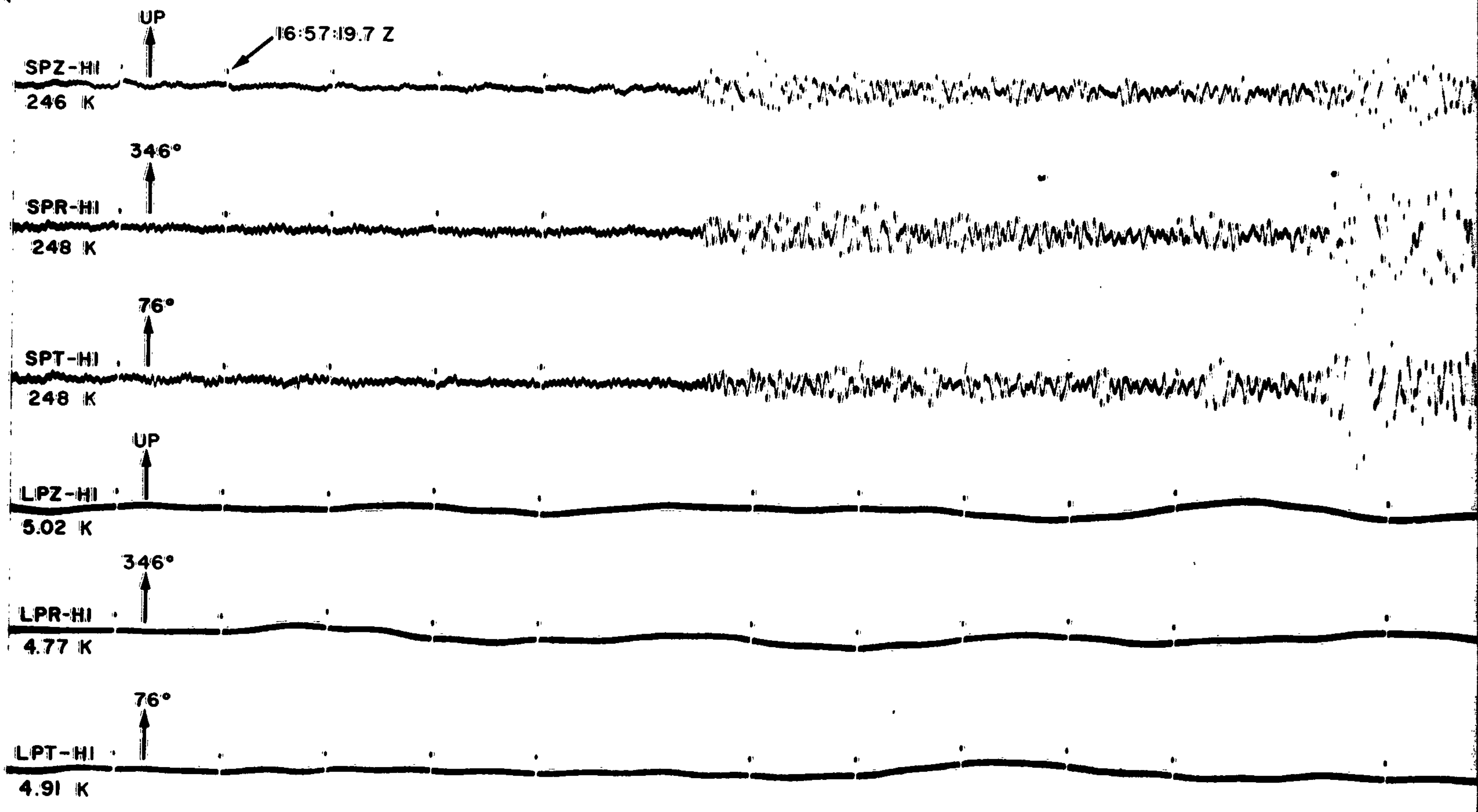
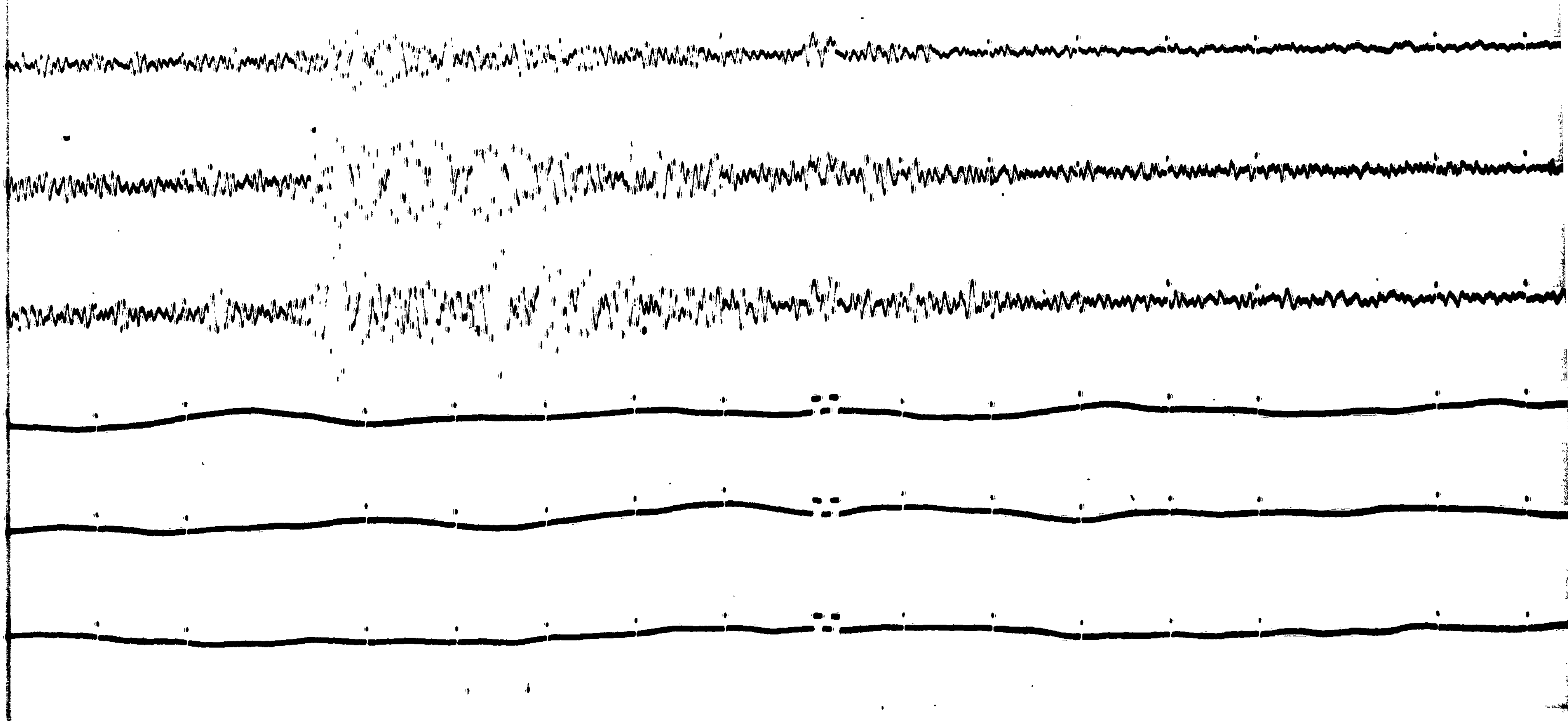


STOAT (COLLAPSE)
WI NV
Winnemucca, Nevada
9 January 1962
Δ=494 km

2



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